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Based on analysis of the Air Force's F-16 program, the report examines initial estimates of two specific component characteristics: maintenance factor and unit price. The report substantiates the usefulness of an availability model in computing the best mix of recoverable spare components for a specified investment level and also demonstrates the usefulness of early operational data in revising initial estimates of component maintenance factors.

TOWARD IMPROVED INITIAL

PROVISIONING STRATEGIES:

THE F-16 CASE

ADA 115824

April 1982

John B. Abell
Joan E. Lengel
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EXECUTIVE SUMMARY

The goal of initial provisioning of spares for a new weapon system is to provide an acceptable level of readiness at least cost, or, conversely, to provide the highest level of readiness for a fixed level of investment. One fundamental provisioning issue is the mix of spares to be procured. Traditional methods determine the mix of spares without considering readiness.

Mathematical models, called availability models, developed in the last decade, make explicit the critical link between readiness and the cost and mix of spares. Their use within DoD has not been required and is still sporadic; however, the Secretary of Defense, in the FY84 Defense Guidance, provided the following direction to the Services:

> "Our objective is to size and fund POS secondary item inventories to support programmed weapon system availability rates and operating tempos. ... the Services will develop and institute, by end FY84, the ability to size weapon system initial and replenishment secondary item inventories to meet explicit weapon system availability and operating tempo objectives."

Availability models are superior provisioning tools because they explicate the readiness-to-investment link. Using an availability model to compute the best mix of spares for a specified provisioning budget should substantially improve the readiness of new systems. Conversely, using one to compute the best mix of spares to achieve a desired level of readiness should keep to a minimum the cost of provisioning a new system.

To test that hypothesis, we examined the provisioning history of the F-16 and the aircraft's first 30 months of operational experience.

First we investigated the accuracy of initial estimates of component characteristics--the estimates upon which provisioning calculations are based. Results were mixed. Price estimates were remarkably accurate, but estimates

of component removal rates (called maintenance factors) averaged four times as high as their observed values in the 30 months of operation. The consequence was an F-16 availability-vs.-cost curve that overstated the spares expenditure required to achieve the availability objective.* We conclude, therefore, that the use of initial estimates to compute an availability-vs.-cost curve should be coupled with an effort to detect and eliminate any systematic bias in those estimates.

Second we investigated how best to compute spares requirements once an investment level is specified. The answer is clear: use an availability model. The resulting mix of spares will provide substantially better weapon system availability and will be less vulnerable to uncertainty than will the mix calculated using traditional methods. We recommend that DoDI 4140.42 be revised to require the use of availability models for this purpose for all new, major weapon-system programs.

Exploring further the problem of biased initial estimates of component removal rates, we found that it can readily be overcome with operational experience. Based on F-16 data, revision of estimates on the basis of as little as one month's experience can greatly improve provisioning decisions, increasing readiness or reducing cost. Revision based on six months' experience is almost as good as that reflecting thirty months' experience. It is an expensive mistake to postpone revising initial estimates.

The method we developed for revising estimates is called BAYES-LIN. In the F-16 application it proved far superior to the weighting factors prescribed by DoDI 4140.42. The BAYES-LIN method should be tested on other

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*As "real-world" availability we used the availability calculated from maintenance factors (i.e., component removals) observed in the F-16 program from July 1979 through June 1981.

weapon-system programs. If its success is repeated, it should be substituted for the method now prescribed.

In summary, our experience with data from the F-16 program illustrates the dramatic improvement that new mathematical tools can make in initial provisioning decisions. Using availability models and techniques for exploiting data from early operational experience can markedly reduce the cost of attaining desired readiness levels for new systems or, conversely, increase the readiness attained for a given level of spares investment. We recommend that the ASD(MRA&L) change DoDI 4140.42 to foster use of the new tools. We also recommend that he sponsor or otherwise encourage development and testing of such methods as BAYES-LIN, to take better advantage of data available during the early life of new systems.

ACKNOWLEDGMENT

We are indebted to our colleague at LMI, Ms. Brenda J. Allen, for her assistance in compiling the cost data used in this report.

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1. INTRODUCTION

BACKGROUND

The analysis described in this report is intended to provide a better understanding of how to devise a spares acquisition strategy for a weapon-system program that will provide an acceptable level of weapon-system availability during the system's early life for the least expected total cost. The terms availability, end-item availability, weapon-system availability, and aircraft availability, used interchangeably here, mean the probability that an end item (for our purposes an aircraft) selected at random is not waiting for a component to be repaired or shipped to it. (We do not mean spares availability, fill rate, or supply effectiveness rate.) Throughout this report, we focus exclusively on recoverable (repairable) items and ignore engines, common items, and consumables.

A spares acquisition strategy involves a sequence of decisions:

a. Determination of required levels of readiness (as reflected by weapon-system availability).

b. Determination of spares investment levels.

c. Estimation of component characteristics.

d. Computation of spares requirements.

e. Revision of initial estimates of component characteristics based on early operational data.

f. Selection of the method of spares procurement.

The determination of the appropriate availability levels for a new weapon system is outside the scope of this report, as is the method of spares procurement; however, we do examine each of the other four components of a spares acquisition strategy.

This work is part of a longer-range LMI research program in initial provisioning. An evaluation of an important spares procurement technique, known as spares acquisition integrated with production (SAIP), is contained in [2]. Extensive discussion of topics c and d, above, may be found in [1]. From this analysis we derive important conclusions on the use of availability models to compute spares requirements and on methods for revising estimates of component characteristics based on early operational data (topics d and e, above). Reference [1] concludes that availability models are useful in determining spares investment levels as soon as component-level data are available, even if those data are only estimates. The current work, based on actual computations of availability-vs.-cost curves for the F-16 aircraft system, leads us to some observations about the investment level problem. We discuss this issue in Chapter 3.

THE CURRENT WORK

This analysis extends our investigation into the application of availability models to initial provisioning. We define an availability model as a mathematical model that maximizes end-item availability for a specified spares investment level, or minimizes spares investment level for a specified level of availability. The remarks made about availability models throughout this report also apply to optimization models that minimize expected (time-weighted) backorders for a specified cost since they compute nearly identical mixes of spares within a given weapon system, as long as those models can readily produce availability-vs.-cost curves. The particular availability model used to support this analysis was developed by LMI and is known as VARI-METRIC. This model was chosen because it is the only availability model that explicitly accounts for uncertainty by assigning a probability distribution to initial estimates of failures. It is documented in summary form in Appendix A.

An availability model produces an availability-vs.-cost curve, each point of which is an optimum in the sense that it represents the maximal availability for that investment level and the least investment required for that level of availability. There is a specified stockage posture associated with each point on the curve. By stockage posture we mean a set of stock levels by component and location.

The current work examines, to some extent, the four components of a spares acquisition strategy that we enumerated on page 1-1. We briefly discuss here the issues we examine in this report with respect to those four components.

Determination of Spares Investment Levels

In our past assessment of the usefulness of availability models in initial provisioning, we suggested that the decision regarding the appropriate level of investment for initial spares should be supported by an availability-vs.-cost curve. In this report, we do not examine specifically the issue of determining the initial spares investment level because, in the F-16 case, that level was established prior to the availability, in January 1977, of component-level data. We do, however, offer some observations on the usefulness of the availability-vs.-cost curves computed from those initial estimates for determining investment levels for future procurements of initial spares.

Estimation of Component Characteristics

In Chapter 2 we compare the initial estimates of F-16 component maintenance factors and unit prices with their observed values, and discuss some of the implications of those differences. We also discuss in Chapter 2 the availability of specific elements of data at various times during the early life of the F-16 and comment on the quality and utility of those data.

Computation of Spares Requirements

In Chapter 3 we investigate the usefulness of an availability model in computing spares requirements (i.e., the stockage posture for a specified investment level) for the F-16 and compare the performance of such a stockage posture with the stockage posture that results from the item-oriented approach prescribed by Air Force Logistics Command Regulation (AFLCR) 57-27, the Air Force's implementation of DoDI 4140.42.

Usefulness of Early Operational Data

Since the need exists in most major programs to compute requirements for additional procurements of initial spares after the initial operational deployment, an important question exists regarding the usefulness of early operational data in revising initial estimates of component characteristics so that such computations could be done more intelligently. We show in Chapter 4 that early operational data are indeed useful for this purpose.

Finally, in Chapter 5, we summarize our conclusions and offer recommendations that we believe would enhance the cost-effectiveness of initial provisioning throughout the DoD.

2. LESSONS LEARNED FROM F-16 INITIAL PROVISIONING

INTRODUCTION

The F-16 program was chosen for this case study because the program is recent and data were available in sufficient detail to support the study. Furthermore, the program has been in operation long enough to have meaningful maintenance data on which we could base our evaluation of alternative spares acquisition strategies. A description of the F-16 program and its initial-provisioning-related milestones are included in Appendix B.

The lessons learned from our examination of F-16 data can be summarized as follows:

- Early price estimates were quite accurate; for 20 SAIP items, the actual prices paid averaged nine percent lower than the estimated price using constant 1976 dollars.
- Early maintenance factor estimates were far from accurate; the average of the ORLA maintenance factors was about four times as large as the average of the observed maintenance factors.

Both of these lessons will be discussed in this chapter, but, first, we describe the evolution of data in the F-16 program.

F-16 COMPONENT-CHARACTERISTIC DATA

Initial provisioning is typically done at a time when the end item (aircraft) is still changing. Engineering changes are being made, item characteristics (maintenance factor, unit price, etc.) are changing, and perhaps deployment plans and other system-level characteristics are not yet finalized. In spite of this, the need exists to provision for spares to support training and readiness requirements. The funding cycle and procurement leadtime for most recoverable items are such that decisions on the levels of spares investments and the mixes of spares to be procured must be made three to five years

before the first end items are scheduled for delivery. There is obviously some uncertainty about any data that exist several years before operational use of the weapon system. It should also be noted that changes can and do occur in both the level of spares investment and the mix of spares procured after the original investment decision and requirements computation.

Portions of data available at various stages of the F-16 program are used in this analysis. The data are described to indicate the difficulty of maintaining accurate component level data. Over the five years during the development of the F-16, the data collection, verification and correction tasks were a substantial undertaking. Each stage represents a time when an increment of data has been developed that increases knowledge about component characteristics.

The component characteristics used in this study are the following: part number (PN); work unit code (WUC); maintenance factor (MF); unit price; source, maintenance, and recoverability (SMR) code; base condemnation rate (BCR); depot condemnation rate (DCR); quantity per aircraft (QPA); procurement leadtime (PCL); order and ship time (OST); depot repair time (DRT); base repair time (BRT); and the not-repairable-this-station (NRTS) rate. Details of these characteristics are presented in Table 2-1.

Stage 1

A detailed comparison of F-16 and F-111F equipment was made at the subsystem level to develop system complexity factors. The F-111F was used because there is a high percentage of common equipment between the two aircraft. The comparison was made for a time period when the F-111F utilization rate was approximately the same as the expected F-16 utilization rate of 30 flying hours per aircraft per month.

TABLE 2-1. COMPONENT CHARACTERISTICS

NAME	DEFINITION	TIME WHEN KNOWN	REMARKS
Part Number (PN)	The contractor's identification of a component	Generally before Full Scale Development (FSD)	May be changed due to modifications and design changes.
Work Unit Code (WUC)	Code used to identify the system, subsystem and reparable component	Generally before FSD	
Maintenance Factor (MF)	Number of failures per 100 flying hours; equivalent to removal rate.	Estimated before FSD, deemed to be mature after two years.	Is always changing, but tends to stabilize when estimated by a two-year moving average.
Unit Price	Price for one component or set of components	Estimated before FSD, usually negotiated before delivery.	May change due to related or unrelated modifications to its contract.
Source, Maintenance and Recoverability (SMR)	Codes defining the source of acquisition and maintenance concept of a component, i.e., whether and where it will be repaired.	Assigned before FSD	
Base Condemnation Rate (BCR)	Percent of removed components condemned at base level	Estimated before FSD, calculated in D041 System	
Depot Condemnation Rate (DCR)	Percent of NRTS components condemned at the depot	Estimated before FSD, calculated in D041 System	
Not-Repairable-This-Station (NRTS) Rate	Percent of removed components that cannot be repaired at the base and are shipped to the depot for repair	Estimated before FSD, calculated in D041 System	
Quantity Per End Item (QPEI)	Number of components per end-item (aircraft)	Before FSD	
Procurement Lead Time (PCL)	The sum of the time to receive the component from the manufacturer once it is ordered plus three months of administrative time	Estimated before FSD	Changes due to modifications and availability of raw material.
Order and Ship Time (OST)	Days to transfer component from depot to base or vice versa	Estimated before FSD	Initially the same constant for all components.
Depot Repair Time (DRT)	Days to repair component at depot	Estimated before FSD, calculated in D041	Initially the same constant for all components. Also called Depot Repair Cycle Time.
Base Repair Time (BRT)	Days to repair component at base	Estimated before FSD, calculated in D041	Initially the same constant for all components. Also called Base Repair Cycle Time.

These comparisons are documented in Volumes 1 and 2 of a General Dynamics report called the AAA Report [9]. The AAA Report contains no component-level data; it simply documents the techniques and methodologies used to evaluate the reliability, capability, status, and problem areas of the F-16 during the definition, design, development, and evaluation phases. Mean flying time between failures (MFTBF) values at this stage were based on historical data from a number of aircraft. Historical component characteristics were modified to estimate F-16 MFTBF based on the complexity of the F-16 (relative to the aircraft from which historical data were drawn), advances in technology, the state-of-the-art of certain equipment in some F-16 systems, and the reliability growth on similiar subsystems and equipments. At this stage, data reflect a combination of historical data, engineering estimates, and the results of flight tests between April and August 1974 (the date of the first draft of the AAA Report).

Stage 2

During 1975, 1976, and 1977 component-level data were analyzed and published as books of Optimum Repair Level Analysis (ORLA)/Depth of Repair Record (DORR) information. The purpose of an ORLA is to determine the optimal repair level of a component based on the life cycle cost. The DORR provides a summary of pertinent information about the component such as the part number, MFTBF, QPA, WUC, contractor and government maintenance factors, NRTS rate, condemnation rate, and SMR code. These ORLA/DORR data (often shortened to ORLA data in this report) were used to analyze spares requirements and determine the number and selection of spares for the first three spares contracts. They were also used in this study to examine alternative spares acquisition strategies.

The ORLA/DORR process is quite complex but is described here because it shows the thoughtfulness and thoroughness used in the F-16 program in developing early estimates of component characteristics. Within General Dynamics (GD) an Engineering/Maintainability group identified recoverable components and collected cost, MFTBF, technical publication requirements, training requirements, and support equipment requirements for each component. The MFTBF was converted to a mean time between corrective tasks (MTBCT) by the following formula:

$$\text{MTBCT} = \text{MFTBF} \div K \quad \text{where}$$

$$K = \frac{\text{MTB Failures}}{\text{MTB Maintenance}} \times \begin{matrix}\text{Equipment}\\ \text{Complexity}\\ \text{Adjustment}\end{matrix} \times \begin{matrix}\text{Non-Spares}\\ \text{Adjustment}\end{matrix}$$

The first factor of the K calculation is derived from maintenance data collected on other aircraft. The second factor is based on engineering judgments by the manufacturer relating to the equipment design and location. This factor is a judgment by the manufacturer based on maintenance experience on similar equipment. The last factor is also a manufacturer's judgment on the adjustments and repairs on the component that will not require a spare item. Therefore, MTBCT represents the expected mean time between demands for a mature system.

All these data were entered into a computer program developed by GD to estimate the ORLA life cycle costs and generate the data for the ORLA/DORR books. The data were reviewed by a team of GD personnel consisting of representatives from Manufacturing, Technical Publications, the F-16 Program Office, Logistics Support, Division Estimation, Engineering/ Support Systems, and Engineering/Maintainability. Once this team reviewed the ORLA/DORR information, it was submitted to the Air Force Resident Integrated Logistics Support Activity (RILSA) for review. At this stage, RILSA personnel reviewed

the contractor's numbers to determine whether their operational (historical) experience agreed with the contractor's estimates of component characteristics.

The team from GD and the RILSA sequentially reviewed the ORLA/DORR books once again and the final, approved ORLA/DORR report was submitted to the government. During the second RILSA review, component maintenance factors were "derated." The RILSA "derated" the estimated maintenance factors to calculate a value for use in supporting initial provisioning requirements because the estimated factors were based on data from mature systems. The derate factors were developed for specific equipment using the concepts of Mr. J. T. Duane. His theory, verified by test at the General Motors Corporation, states that new equipment reliability will increase during the early development stages as $y = bx^{\alpha}$ (where in this case y = MTBCT, b = the initial value of MTBCT, α = the reliability growth rate and x = cumulative flying hours). Since the derated maintenance factors were not yet available in January 1977 (the date we assumed for initial provisioning in our analysis), we used the factors without derating in our calculations. The derated maintenance factors would have been even more pessimistic.

Stage 3

The next increment of data was collected between April and December 1978 at the Full Scale Development (FSD) Air Vehicle Reliability Demonstration. The tests performed during this period conformed to the appropriate military standards. The tests were designed to determine whether subsystems met the FSD MFTBF goals promised in the contract and the AAA Report. Reliability was thus demonstrated at the subsystem rather than the component level.

Stage 4

The Integrated Logistics Data File (ILDF) system documents changes to component characteristics since the first aircraft was delivered to Hill Air Force Base in January 1979. The ILDF contains historical records of all F-16 components. The records include links that show the item that replaced a given component or was replaced by that component. The most recent component characteristics for a given part number are stored in the file. The file is updated, as often as weekly, based on information provided by GD. The ILDF would be an excellent source of data. It tracks changes in component characteristics such as cost, maintenance factor, NRTS rate, condemnation rate, and design changes. It is a single source of data that could provide vital information on the steps taken during the F-16 program. Unfortunately, much of the data about a component are missing and there is no way to associate a date with the data. The date does not indicate the date of the last change to a field; that is, pertinent fields do not have a change date attached to the field. Maintaining a complete ILDF is a very large task of verification and correction as well as of computer storage and cost. Despite this omission, we found ILDF data useful in determining the procurement leadtime for components and in tracing part number changes so that the data used in our analysis was consistent over different time periods.

Stage 5

Air Force data systems track maintenance actions on all active aircraft. Maintenance data are available from each installation, from the AFLC D056 system, and also from a contractor, Dynamics Research Corporation (DRC), in a consolidated form. Normally maintenance data are also available in the D041 system, but for the F-16 our most recent D041 tapes (as of September 1979) had very little data. The DRC data were readily available, so

DRC's data were used in this analysis. Besides the ILDF data, a GD document called "Work Unit Code/Work Breakdown Structure Cross Reference Listing for the F-16 Line Replaceable Units" [10] provided cross-reference information so that, except for a few components that were recently added to or deleted entirely from the aircraft, a comparison of ORLA/DORR data and maintenance data can be made. The data extracted from DRC's F-16 Centralized Data System (CDS) include the number of maintenance actions by action-taken code, by month, by component (WUC), for all failure types. The flying hour program for each month was also extracted.

We now discuss the results of our analysis of F-16 component-characteristics data with respect to initial estimates of maintenance factors and unit costs and their observed values.

COST ANALYSIS OF SELECTED ITEMS

We conducted a limited analysis of F-16 cost data because (1) prices paid were not readily available and (2) some prices are still not yet definite. We selected 20 SAIP items that are either expensive or high-demand items. We further converted all prices to 1976 constant dollars using Air Force inflation indices for replenishment spares. The selected items were paid for during 1977 to 1980 and the following indices were used: 1976-1977, 3.27 percent inflation rate; 1976-1978, 12.33 percent inflation rate; 1976-1979, 19.75 percent inflation rate; and 1976-1980, 26.5 percent inflation rate. Table 2-2 lists the SAIP items we analyzed based on USAF SAIP options I, II, and III. Comparing the 1976 (ORLA) price estimates to the average of the actual price paid (in 1976 dollars), nine of the 20 items had a price increase, the remaining 11 items had a price decrease. The net change in total cost (in 1976 dollars) for the items purchased is a nine percent decrease. The net change in total cost in current dollars is a 16.8 percent increase.

TABLE 2-2. PRICE DATA FOR SELECTED SAIP (I, II, III) ITEMS

Prices in 1976 Dollars

Nomenclature	Total Quantity Ordered	ORLA Unit Price Estimate	SAIP II Unit Price Estimate	Average Unit Price Paid	Price** Paid Range
Nose Radome Cover	20	$ 14,232	$ 27,807	$ 10,714	$ 12,883 - 15,377
Canopy Assy. (F-16A)	9	24,711	50,082	40,164	54,641 - 54,655
Canopy Assy. (F-16B)	16	39,277	85,677	40,735	46,386 - 56,574
Aft Fixed Transparency	46	3,142	2,801	1,748	1,702 - 2,267
Main Landing Gear Wheel Assy.	582	532	2,507	1,581	1,679 - 1,953
Flight Control Computer	80	29,281	45,457	40,166	41,184 - 56,804
Integrated Rudder Servo Actuator	27	21,545	27,977	19,418	19,321 - 24,753
Horizontal Stabilizer	14	20,173	40,595	16,601	16,548 - 22,980
Bleed Air Power Unit	15	16,500	30,663	20,910	22,739 - 29,222
Jet Fuel Starter Assy.	59	23,000	1,991*	18,283	19,795 - 25,788
Accessory Drive Gearbox	27	12,700	67,347	30,182	17,304 - 54,465
Hydraulic Reservoir	90	1,270	1,849	1,532	1,567 - 2,051
Attitude Director Indicator	174	4,061	5,175	2,429	2,668 - 3,208
Central Air Data Computer	36	25,625	27,858	15,676	14,174 - 20,882
Digital Signal Processor	40	60,645	119,498	64,959	73,724 - 107,646
Heads-Up Display Unit	96	41,012	40,448	27,369	28,463 - 41,565
Heads-Up Display Electronics Unit	45	41,398	47,822	31,158	32,949 - 52,926
Inertial Navigation Unit	77	156,051	169,674	125,548	147,432 - 193,166
Hydraulic Drive	18	18,875	6,203	4,991	5,204 - 5,833
Radar/Electro-Optical Display Unit	216	10,739	10,843	12,667	8,192 - 26,592

Total Number of Units Ordered	1,687
Total Price Using ORLA Estimates	$31,388,221
Total Price Paid	$28,651,169
Total Price Using SAIP II Estimates	$39,725,232

* This appears to be a mistake in the MOD-METRIC price input
** In then current dollars

MAINTENANCE FACTORS

The maintenance factors observed are 0.257 times the estimated (ORLA) maintenance factors on average. Table 2-3 shows the estimated and actual observed maintenance factors for different time periods for various subsystems of the aircraft. Before one examines the table in detail, it is important to understand the method used to calculate maintenance factors.

Maintenance factors were, as mentioned previously, derived from DRC's CDS file of all maintenance actions from 1 January 1979 to 30 June 1981. We used only those records with action-taken codes A, B, D, E, F, G, H, J, K, L, P, Q, R, S, T, U, V, W, Y, Z, and 1-9. We used the shop repair action-taken codes rather than action-taken code C, because it appeared that using action-taken code C would seriously undercount the number of maintenance actions taken. In other words, data inconsistencies led us to believe that using code C would be misleading. Codes M, N, and X were excluded because they do not represent component repairs. Appendix C contains the definitions for each of the action-taken codes and shows the overlap or redundancy resulting from using all codes.

Furthermore, our analysis omitted the main landing gear tire and the wheel assembly because there were no maintenance actions recorded for these two items for the first nine months. The analysis also omitted the batteries. The next section will explore missing and misleading data in more detail.

Even after maintenance factors were computed correctly, i.e., without double counting or obvious data inconsistencies, the result remained: ORLA estimates are four times as great as those calculated using actual maintenance records. After checking another source (the D056 data system) to insure that the CDS data captured all maintenance records, we examined component data. We found several items for which the ORLA estimate appeared to be illogically

TABLE 2-3. SUBSYSTEM LEVEL AVERAGE MAINTENANCE FACTORS

WUC	ORLA	1 Month	3 Months	6 Months	12 Months	30 Months
11000	.0130	.0000	.0000	.0012	.0015	.0008
12000	.1896	.0000	.0000	.0000	.0013	.0015
13000	.0532	.0000	.0190	.0241	.0219	.0179
14000	.0973	.0000	.0406	.0233	.0327	.0265
23000	.0786	.0000	.0708	.0764	.0384	.0273
24000	.0765	.0000	.0291	.0400	.0339	.0238
41000	.0634	.0000	.0151	.0154	.0116	.0151
42000	.1152	.0000	.0695	.0354	.0232	.0195
44000	.1872	.0000	.0000	.0189	.0209	.0196
45000	.0608	.0000	.0000	.0000	.0088	.0118
46000	.0624	.0555	.0414	.0197	.0251	.0177
51000	.0740	.0000	.0000	.0097	.0151	.0197
55000	.0120	.0000	.0000	.0000	.0000	.0037
64000*	.0877	.0000	.0000	.0346	.0226	.0160
74000**	.1414	.1613	.0928	.0893	.0663	.0483
75000	.0695	.0000	.0693	.0551	.0486	.0267
76000	.0897	.0000	.0679	.0259	.0245	.0082
TOTAL SYSTEM AVERAGE	.0852	.0345	.0378	.0336	.0287	.0212

*Combined with WUCs for 62000 and 63000 Subsystems
**Combined with WUCs for 71000 Subsystem

high. For instance, the landing light assembly had an estimated ORLA maintenance factor of 0.334 per hundred flying hours. This is 91 times the observed maintenance factor to date of 0.00366. This assembly consists of a sealed beam lamp and transformer in an aluminum case bolted to the left main landing gear strut. Although the entire assembly may be removed, repair is usually accomplished by replacing the sealed beam lamp or other consumable piece parts. Similarly, covers and doors, which are frequently removed to repair items behind them but seldom need to be replaced, had ORLA maintenance factors that were, on the average, 13 times higher than the observed factors.

One other possible source of error in determining requirements relates to the pipeline constants used in 1976-77. In our analysis we used the order-and-ship, base repair, and depot repair times specified in the programming checklist and in specific instructions for computing initial spares requirements for the F-16. We did not compare these estimates to the times observed for base repair, depot repair, etc. However, since the depot and the first base to received F-16s are collocated (Hill AFB), data for essentially the first year reflect aircraft at one location.

MISSING/MISLEADING OPERATIONAL DATA

We excluded the main landing gear tire and the wheel assembly as well as the aircraft batteries from most of our analysis of F-16 spares requirements. They were excluded for differing reasons. The main landing gear tire and the tire-and-wheel assembly had no maintenance actions recorded in the first nine months of aircraft operations. We confirmed that this glaring omission was also discovered by the Air Force and was subsequently (by the tenth month of operation) corrected. Since much of our analysis focuses on the use of early operational data, we eliminated the main landing gear tire and the tire-and-wheel assembly from our analysis.

The batteries suffered from a different problem. The operational data showed that the flight control batteries (four per aircraft) spent an inordinate amount of time (typically in eight hour intervals) in maintenance. When questioned about this, the Air Force confirmed that they had had problems with the batteries. The flight control batteries are turned on by a switch that closes when the nose landing gear strut extends. It was intended that the switch be closed only when the aircraft is in flight. In fact, however, it closed whenever the aircraft was jacked up and opened and closed repeatedly during taxi, takeoffs, and landings. As a result, the batteries went dead often and did not seem to hold their charge. The problem was finally diagnosed and corrected. In addition, problems with the main aircraft battery and its ability to hold a charge existed. The batteries were therefore removed from our analysis.

Some components with missing data were not excluded from our analysis. Reliability improvement warranty (RIW) items, usually line replaceable units (LRU), are items that were identified early as potential problems to overall aircraft reliability. These items were placed under a special contractual incentive to improve their reliability. For the first 18 to 24 months of F-16 operation the LRU failures were reported by Air Force maintenance personnel and are in the data. However, the contractor repaired the shop replaceable units (SRUs) within the LRU. There was a delay in the contractor's reports of which SRUs failed so that some of these failures were not reported before January 1981.

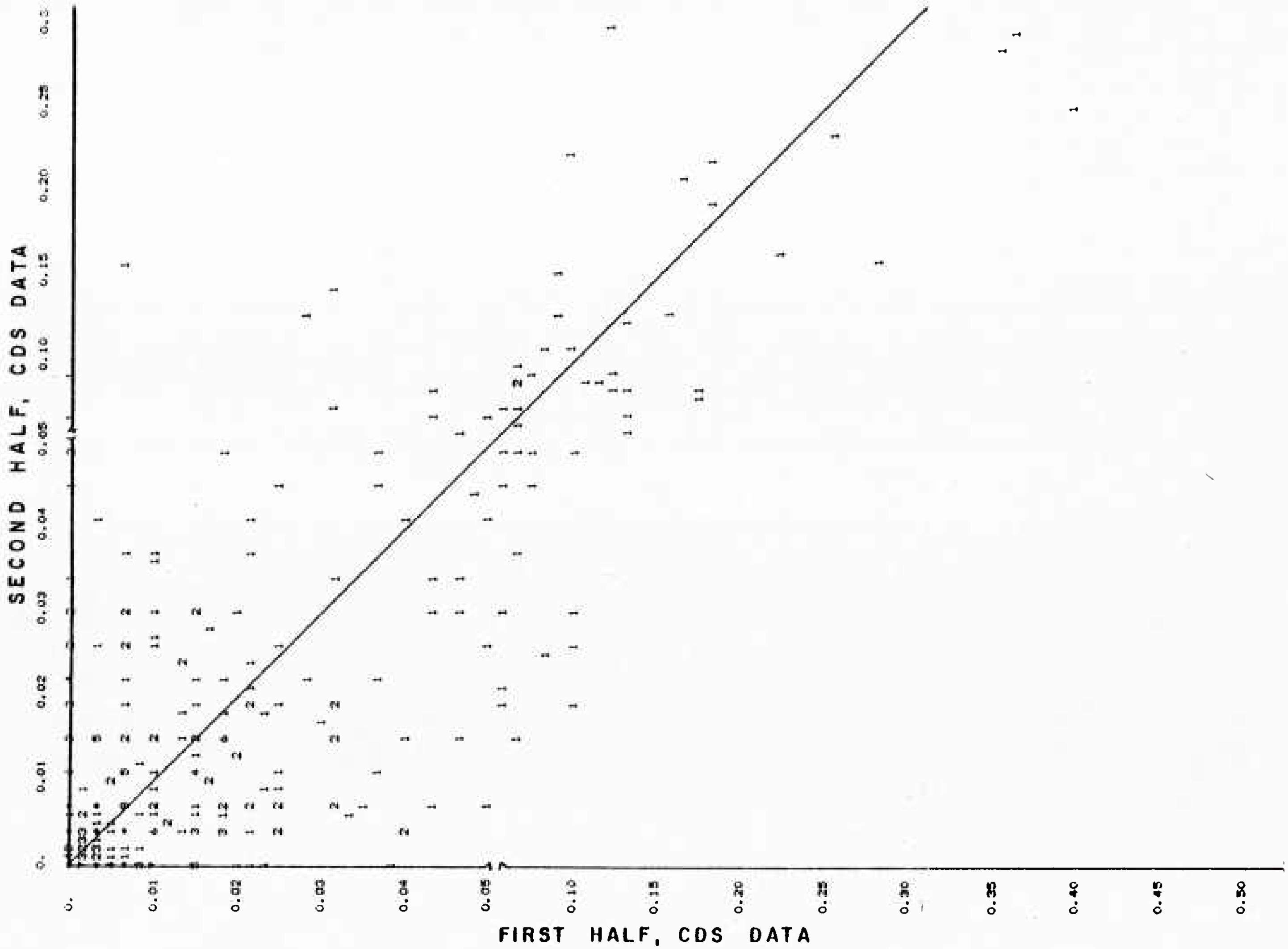
Finding these two problems -- one of missing data and one of misleading data -- prompted us to analyze the operational data further. In particular, we compared the maintenance factors from the first half of the flying hour program (27,867 hours flown during the first 23 months) and the second half of

the flying hour program (26,711 hours flown during the last seven months). The plot in Figure 2-1 shows the two sets of maintenance factors. Their means are 0.0220 and 0.0202 (within nine percent of each other) and their correlation coefficient is 0.947. Therefore, we conclude that the omission of records observed for the tires did not exist in general.

Dealing with misleading data is more difficult. In a practical sense, problems with a particular component due to a design deficiency will manifest themselves. This is especially true for an item that is "flying" more hours than it was designed to fly, for example the batteries that were erroneously using power when the aircraft was jacked up.

Other early data are misleading because of the non-stationarity of the failure rates of components (for example, batteries seldom fail when they are new, but they certainly do fail). The provisioner must not mistake the lack of early failures (on items such as a battery) for a zero failure rate. We found many items, especially on the airframe, with no maintenance actions. Failures of these items are likely to be random and infrequent. The fact that they are not replaced during a certain time period is useful in predicting their actual mean times between failures and thus their maintenance factors. The use of early operational data is discussed in Chapter 4.

FIGURE 2-1 OBSERVED MAINTENANCE FACTORS



3. THE USE OF AVAILABILITY MODELS IN INITIAL PROVISIONING

INTRODUCTION

An availability model is a mathematical model that determines the relative worth-versus-cost of a wide range of possible quantities of spares of each of a system's components and finds the optimal mix of spares for any specified level of weapon-system availability. Thus, availability models take a system view in that they look across all of the components in a system and take explicit account of both cost and readiness in computing the best spares mix. In this chapter, we examine in detail two different approaches to the computation of requirements in initial provisioning. One approach involves the use of availability models. The other approach is an item-oriented approach as prescribed by DoDI 4140.42. The remainder of this chapter will demonstrate, for the F-16, the superiority of stockage postures computed by using an availability model.

In this chapter, we first discuss the item-oriented approach established by DoDI 4140.42 and calculate the predicted availability of the F-16 (based on F-16-peculiar recoverable items) using three interpretations of the Air Force regulation that implements DoDI 4140.42. We then explain our calculation of "actual" availability, the measure we use to compare methods. Finally, we compare the best of the item-oriented methods to an availability model. From this comparison we draw some conclusions about the usefulness of availability models in computing spares requirements and in determining the level of investment for spare components.

STOCKAGE POSTURES USING AFLCR 57-27

DoDI 4140.42 (August 1974) establishes DoD policy relative to stockage criteria and the determination of requirements for secondary item spare and

repair parts. Air Force Logistics Command Regulation (AFLCR) 57-27 provides policy and procedures for determining initial requirements for Air Force expense, investment, and equipment items. The policy prescribed in DoDI 4140.42 relating to initial spares/repair part requirements, is implemented by AFLCR 57-27. The earliest computation of spares requirements for the F-16 aircraft was based on AFLCR 57-27 which provides for the use of models as well as its set of computational rules. We have designated the computational rules "57-27" and called any model approved for use under AFLCR 57-27 by the model's name. The computation of the first spares requirements, SAIP I, followed the 57-27 instructions for recoverable items. Exceptions to the 57-27 instructions, as well as specific worksheets, were published in Reference [11] for F-16 initial spares. One notable exception to 57-27 instructions is that the procurement of the depot stock level requirement was deferred for USAF-managed items. Figure 3-1 shows the ground rules for the initial provisioning computations for the F-16. Figure 3-2 shows the F-16 computation worksheet. These computations omit the following AFLCR 57-27 factors because the procurement of a 30-day depot stock level was deferred:

- Procurement Cycle/Safety Level for depot level maintenance (DLM) program
- Leadtime DLM program

In addition, Depot Repair Cycle Requirements, Floating Stock Level Requirements, War Readiness Materiel, and the 57-27 "Other" category are not applicable for F-16 initial requirements computations.

The Air Force only used 57-27 to calculate spares requirements for the first 38 aircraft for the first year. A MOD-METRIC program was used to determine subsequent spares requirements. However, we calculated the spares

FIGURE 3-1. GROUND RULES FOR USAF F-16 SPARES COMPUTATIONS FOR RECOVERABLE ITEMS*

Excerpt I

1. Factors and programming will normally be based on maintenance period of 100 hours.
2. Quantity per component will be the quantity per each next higher recoverable assembly.
3. All computations will be rounded to the next unit pack.
4. Quantities will be rounded up at 0.5; 0.5 or greater will be increased to next whole number.
5. All segments will be rounded to one decimal place.
8. Factors and rates will be rounded to four decimal positions.
10. All condemnation on recoverable split repair will be considered at depot level.

Excerpt II

	ERRC** "C"	ERRC "T"	ERRC "L"
Depot Repair Cycle:			
Organic	52 days	55 days	52 days
Base Stock Level:			
Base OST	5 days	12 days	12 days
BRC	2 days	5 days	2 days
Overhaul Stock Level	12 days	12 days	12 days
Depot Stock Level (See Note 3)	30 days	30 days	30 days

Note 3: The depot stock level requirement will be deferred from procurement for USAF items.

*Excerpted from Reference [11]

**Part of the source, maintenance, and recoverability (SMR) code.

USAF/EPG
COMPUTATION PROCEDURE FOR
RECOVERABLE CONSUMPTION ITEMS

T, C, L 6TH POSITION SMR CODE
(EXCLUDE IF D IN POSITION 3)

RATES

$$\left\{ \frac{\text{NRTS}}{\text{MF}} + \left[\frac{\text{BCP}}{\text{DDR}} \times \left(1.00 - \frac{\text{NRTS}}{\text{BRR}}\right) \right] \right\} \times \overset{\text{MF}}{\_\_\_\_} = \overset{\text{D}\overset{\text{D}}{\cancel{\text{R}}}\text{R}}{\_\_\_\_}$$

____ - ____ = ______________

MF [(DCR X NRTS) + (1.00 - NRTS) X BCP] WOR

____ X ______________________ = ________________

FORMULA

$$1.\quad \left[\overset{\text{LT}}{\_\_\_\_} + \overset{\text{SL}}{3} \right] \times \overset{\text{AMP}}{\_\_\_\_} \times \overset{\text{QPEI}}{\_\_\_\_} \times \overset{\text{WOR}}{\_\_\_\_} \times \overset{\text{NOA}}{\_\_\_\_} = \_\_\_\_\_\_\_\_ \text{ Operating Qty}$$

$$2.\quad \overset{\text{AMP}}{\_\_\_\_} \times \overset{\text{QPEI}}{\_\_\_\_} \times \overset{\text{MF X NRTS}}{\_\_\_\_\_\_} \times \frac{\overset{\text{DRC}}{\_\_\_\_}}{30} \times \overset{\text{NOA}}{\_\_\_\_} = \_\_\_\_ \text{ DRC QTY}$$

$$3.\quad \left[\left(\overset{\text{12 DO\&ST}}{\_\_\_\_\_} \times \overset{\text{DDR}}{\_\_\_\_}\right) + \left(\overset{\text{10 DBRC}}{\_\_\_\_\_} \times \overset{\text{BRR}}{\_\_\_\_} \times \frac{\overset{\text{BRC}}{\_\_\_\_}}{10}\right) \right] \times \overset{\text{QPEI}}{\_\_\_\_} \times \overset{\text{NOA}}{\_\_\_\_} = \_\_\_\_ \text{ BS}$$

$$4.\quad \overset{\text{AMP}}{\_\_\_\_} \times \overset{\text{QPEI}}{\_\_\_\_} \times \overset{\text{DDR}}{\_\_\_\_} \times \overset{\text{NOA}}{\_\_\_\_} = \_\_\_\_ \text{ DSL QTY}$$

SUM of 1. OP, 2. DRC, 3. BSL, and 4. DSL = ____ TOTAL REQUIREMENTS

FIGURE 3-2. F-16 REQUIREMENT COMPUTATION WORKSHEET

using 57-27 for the entire two-year initial provisioning period for illustrative purposes. Table 3-1 shows the results of our analysis of 57-27 spares requirements. The methodologies and evaluation techniques will be discussed below. As mentioned previously, none of the calculations here duplicate F-16 spares requirements calculations since the Air Force switched to the use of MOD-METRIC. The use of an approved model is authorized by both AFLCR 57-27 and DoDI 4140.42.

TABLE 3-1. AVAILABILITY UNDER DoDI 4140.42 ITEM-ORIENTED APPROACH

Method	Time Period	Resulting Budget	"Actual" Availability
F-16	2 Years	$18.04M	31 percent
57-27	2 Years	11.06M	19 percent
57-27(M)	2 Years	28.13M	48 percent

57-27 SPARES REQUIREMENTS EVALUATION

We followed three slightly different methodologies to calculate spares requirements using AFLCR 57-27. These methodologies duplicated the calculations (1) specified for the F-16, (2) specified by AFLCR but constrained by F-16 ground rules, and (3) modified to provide a pipeline of spares. The three methodologies reflect three different interpretations of AFLCR 57-27. Though the actual formulae used differ very little, they result in a wide range of budgets and availabilities.

For all three calculations we used the flying hour program specified in Revision 2 of the Programming Check List (PCL), dated December 1976. The flying hour program and the delivery schedule used are shown in Table 3-2. These data were used in all our analyses, except that actual hours flown were used to calculate observed maintenance factors.

TABLE 3-2. FLYING HOURS AND AIRCRAFT DELIVERY SCHEDULE*

DATE	AIRCRAFT DELIVERY SCHEDULE F-16A	F-16B	TOTAL SCHEDULED AIRCRAFT AT END OF MONTH	MONTHLY SCHEDULED FLYING HOURS
78 Sep	2	0	2	0
Oct	0	1	3	32
Nov	0	1	4	53
Dec	0	0	4	74
79 Jan**	0	1	5	74
Feb	1	1	7	95
Mar	1	1	9	132
Apr	1	2	12	169
May	2	2	16	246
Jun	3	3	22	328
Jul	2	2	26	426
Aug	3	3	32	524
Sep	3	3	38	635
Oct	4	3	45	855
Nov	4	3	52	1000
Dec	5	3	60	1158
80 Jan	6	2	68	1389
Feb	6	2	76	1471
Mar	7	2	85	1623
Apr	8	2	95	1803
May	8	2	105	2011
Jun	9	2	116	2219
Jul	9	2	127	2427
Aug	9	2	138	2654
Sep	10	2	150	2880

* As of December 1976

** First aircraft actually delivered

The first method, labeled F-16, follows the worksheet in Figure 3-2. The factor, average month flying hour program (AMP), is the product of the average month's inventory and the average month's utilization rate (average flying hours in the month). The flying hour programs for the F-16A and F-16B differed and are combined in the analysis.

The second method, labeled 57-27, follows the rules set forth in Figures 3-1 and 3-2, except that the DRC Quantity was changed to conform to the definition in AFLCR 57-27. Thus, Item 2 in Figure 3-2 was changed to read as follows:

PMP x QPEI x MF x NRTS x (1-DCR) x DRC x NOA = DRC QTY.

Also, the peak month flying hour program (PMP) is used in both Items 1 and 2 in place of the AMP (to conform with AFLCR 57-27). The PMP is similar to the AMP but is defined as the product of the average number of aircraft at the end of the month and the average flying hours (F/H) per aircraft over two years.

The third method, labeled 57-27(M), is the same as 57-27 except that it uses a different definition of PMP. The modified PMP is defined as the product of the number of aircraft at the end of two years (i.e., 150) and the average F/H per aircraft over the entire two-year time period. This simulates continued operation of the aircraft so that a pipeline of spares can be calculated. The 57-27(M) method provides for a pipeline of spares for the aircraft at the end of the two-year initial provisioning period. This is consistent with the Air Force's philosophy of end-item support; therefore, the 57-27(M) method for the two-year time period will be used for comparative purposes with the availability model results discussed in the following section.

One other item of Table 3-1 must be defined, the data labeled "Actual" Availability. Throughout the analysis we evaluated stockage postures using a specific estimate of actual failures. We now discuss this measure of performance.

COMPUTATION OF "ACTUAL" AVAILABILITY

The calculation of the "actual" availability is based on the failures observed and reported in DRC's CDS data file described in Chapter 2. As mentioned previously, after four components were removed from the analysis, the data were consistent between the first and second halves of the flying hours flown. In an effort to use as much data as possible without introducing possible bias by using all 30 months of the data, we chose the last 24 months of data on which to base the performance evaluation. Approximately one third of the components had no failures during the last 24 months (also during the full 30 months), but based on the 53,615 hours actually flown during the period, these components could not be assigned an actual failure factor of zero. In fact, the "actual" availability was computed using maintenance factors revised in a Bayesian sense. The method of Bayesian revision is discussed in detail in Chapter 4.

We used the VARI-METRIC model throughout this report to calculate the availability that could be expected to be delivered by a stockage posture. VARI-METRIC calculates an "actual" availability by computing the expected backorders (EBO) for each component, given its asset position (number of each item purchased) and the revised maintenance factor. In this application, VARI-METRIC is used in an evaluative, rather than optimizing, mode. Thus the "actual" availability is a prediction of what availability would have been delivered by a particular stockage posture at the end of the initial provisioning period based upon maintenance factors being determined by a

Bayesian weighting of the initial estimates and the observed failures in the last 24 months of the CDS data.

To summarize the findings concerning item-oriented approaches when evaluated against the "actual" failures as described above, we again refer to Table 3-1. In each method, the "actual" availability was less than 50 percent; that is, had any of these methods been used for initial provisioning, the stockage posture computed would have resulted in a low "actual" availability for the F-16. Had the ORLA estimates used in the calculations of the various interpretations of the AFLCR 57-27 methods been accurate, rather than consistently overestimated, the "actual" availabilities would have been even lower. The "actual" availability was as high as it was because not as many failures occurred as were expected.

STOCKAGE POSTURES USING AN AVAILABILITY MODEL

There are a number of multi-echelon inventory models that could be used for initial provisioning. In initial provisioning, only one estimate of the maintenance factor exists, and there are no operational data available to calculate a mean maintenance factor. Therefore, a model that takes explicit account of the uncertainty about the estimated maintenance factors is preferable to one that does not. The VARI-METRIC Model developed by LMI in 1980 is essentially the same as certain other models except for its explicit consideration of the uncertainty about demand rates. VARI-METRIC is discussed in more detail in Appendix A.

For a given budget VARI-METRIC generates a stockage posture. Associated with this stockage posture is a predicted availability. We evaluated this stockage posture using a probability distribution based on the reported maintenance actions observed in the 24 months from 1 July 1979 to 30 June 1981, as described previously.

Table 3-3 compares VARI-METRIC with the 57-27(M) method. The table shows the superiority of VARI-METRIC over 57-27(M).

TABLE 3-3. COMPARISON OF VARI-METRIC WITH 57-27(M)

Method	Budget Level	Predicted Avail-ability	"Actual" Avail-ability
VARI-METRIC	\$28.07M	0.065	0.58
57-27(M)	\$28.13M	-	0.48

TECHNICAL NOTE

The use of VARI-METRIC requires the specification of the parameter, α. α is the shape parameter of the probability distribution that is assigned to the maintenance factor. If we assign $\alpha = 1$, then the probability distribution is fairly broad, indicating substantial uncertainty. The larger α, the more certainty we ascribe to our prior estimate of the maintenance factor. The data in Table 3-4 show how the performance of VARI-METRIC changes with changing values of the shape parameter. The goal is to find a value of α such that the model predicts an availability that is consistent with the actual, reported maintenance actions.

TABLE 3-4. THE INFLUENCE OF THE SHAPE PARAMETER ON VARI-METRIC PERFORMANCE

Shape Parameter	Budget Level	Predicted Avail-ability	"Actual" Avail-ability
$\alpha = 1$	\$28.07M	0.065	0.58
$\alpha = 1$	\$30.00M	0.078	0.61
$\alpha = 2$	\$30.00M	0.186	0.67
$\alpha = 10$	\$30.00M	0.464	0.74
$\alpha = 2000$	\$30.00M	0.637	0.76
$\alpha = 1 + 2 \times MF$	\$30.00M	0.139	0.66
$\alpha = 1 + 10 \times MF$	\$30.00M	0.266	0.72

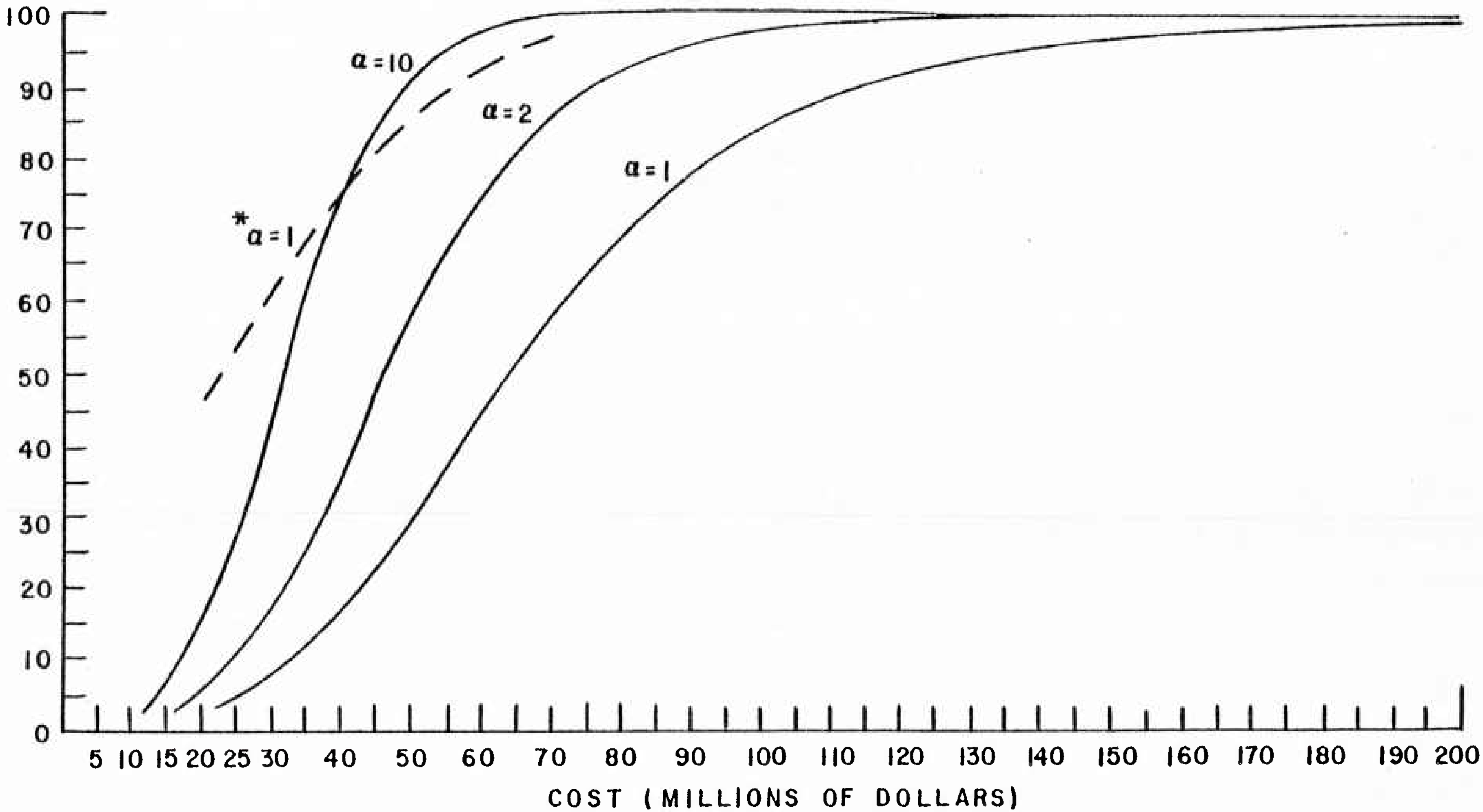
We caution the reader not to conclude from these data that a large value of α will yield the best stockage posture in general. That is not the case. The reason for that phenomenon in the F-16 case is the powerful, systematic, positive bias in the maintenance factors. Without the bias, a value of $\alpha = 1$ yields a stockage posture that is significantly less vulnerable to uncertainty than one computed with higher values of α.

<u>SUMMARY</u>

Our first hypothesis was that an availability model computes a stockage posture that results in a higher availability than the stockage posture prescribed by AFLCR 57-27 for the same investment level. The stockage posture from the availability model is superior; however, because of the bias in the maintenance factors, the model did not predict the "actual" availability well. Some errors are worse than the difference in average maintenance factors indicates. Actual maintenance factors are up to 100 times smaller than ORLA estimated maintenance factors. (Appendix D contains a list of every component used in our analyses along with its estimated and observed maintenance factors.) When VARI-METRIC takes this amount of uncertainty into account, the cost must increase to meet a specified level of availability. Figure 3-3 shows availability-vs.-cost curves for different methods.

The item-oriented approach of DoDI 4140.42 does not take end-item availability explicitly into account. Thus, predicted availability is not a part of the spares requirements computation. Availability models, naturally, do predict an availability. Had an availability model been used under the circumstances presented in our discussion so far, the investment level would have been in the range of \$70M - \$100M, depending on the α chosen, rather than the \$28M of the 57-27(M) method. As can be seen in Figure 3-3, a budget level of \$100M would give a predicted availability of about 85 percent, the F-16

FIGURE 3-3 PREDICTED AVAILABILITY (ORLA MF)



* "ACTUAL" AVAILABILITY

availability goal after two years [12]. The dashed line in Figure 3-3 shows the "actual" availability of the spares posture when $\alpha = 1$.

Figure 3-3 and Table 3-3 may give the erroneous impression that a large value of α yields the best stockage posture. That this is true for the F-16 is due to the positive bias in the maintenance factors. It is not true in general. In fact, we are convinced that setting α equal to 1.0 yields a stockage posture that is substantially less vulnerable to uncertainty than stockage postures computed with larger values of α.

While availability models provide a superior stockage posture, these models, like all other methods of computing initial provisioning requirements, must have some reasonable data, in particular maintenance factors, on which to base their analysis. The next chapter discusses the use of early operational data in improving maintenance factor estimates.

INVESTMENT LEVELS USING AN AVAILABILITY MODEL

The first spares budgeting and initial provisioning planning for the F-16 was done in July 1975. At that time the initial provisioning budget (BP-16) was estimated at 16 percent of the aircraft flyaway cost.

The initial ORLA estimates were not developed until a year later; therefore, an availability model such as METRIC, VARI-METRIC, MOD-METRIC, or SESAME that depends on component-level data for its computations could not have been applied to the earliest determination of an initial spares investment level in the F-16 case. The question remains, however, whether such a model would be useful later for determining investment levels for initial stocks of spares to support future deployments of the weapon system.

An availability model is clearly a powerful tool for determining spares investment levels once component-level data are available. Its power lies in the fact that it makes visible the availability-vs.-cost relationship;

however, the F-16 experience points out a possible pitfall associated with the use of initial estimates of component characteristics. As discussed earlier, component prices seem to have been estimated satisfactorily, but maintenance factors were not. For other weapon systems, the quality of the initial estimates might be very different. For this reason, as much other information as may be available should be used in conjunction with availability-vs.-cost curves in reaching investment decisions. For example, the accuracy of the curve should be verified intuitively by computing the implied cost for, say, 90 percent availability and viewing it as a percentage of end-item cost to see if it is consistent with past experience on other weapon systems that had high initial availability. Additional intuition about the accuracy of the availability-vs.-cost curve can be gained simply by comparing the system-level reliability to the reliability implied by the component maintenance factors. In the F-16 case General Dynamics, in [5], recommended that a mean flying time between failures (MFTBF) of 2.9 be included in the weapon-system specification. This is roughly consistent with the MFTBF of 5.82 that was actually observed on the 810 items during the period 1 January 1979 - 30 June 1981. That is, the MFTBF of 2.9 proposed by General Dynamics is consistent with an allocation to the 810 recoverable components peculiar to the F-16 of roughly half of the total failures on the aircraft. This seems reasonable to us. However, a calculation of the aircraft MFTBF using the estimated (ORLA) maintenance factors yields an MFTBF of 1.45. Taking into account the approximately 1200 common recoverables and all of the consumables would imply an estimated MFTBF well below 1.0. Thus, some very simple arithmetic applied to the ORLA maintenance factors would have strongly suggested that they were, on the average, greatly inflated. (To say inflated by a factor of four would be a bit presumptuous given our hindsight; nevertheless, that is exactly what the

arithmetic would have suggested even in 1977.) Note that all of this discussion ignores K factors, derate curves, reliability growth, etc. We are simply suggesting that, when an availability-vs.-cost curve is used to determine a spares investment level prior to the availability of operational data, i.e., with initial estimates alone, then those estimates should be corroborated, at least intuitively. Furthermore, as we demonstrate in the next chapter, early operational data are very useful in revising initial estimates; therefore, if such data are available at the time of an investment-level decision, the use of an availability model, supported by initial estimates <u>modified by the operational data</u>, would be preferable to any other strategy for determining the investment level.

4. USEFULNESS OF EARLY OPERATIONAL DATA IN REVISING ESTIMATES OF COMPONENT CHARACTERISTICS

In this chapter we explore the application of a well known, well developed body of theory known as Bayesian learning to the question of how one can best use early operational (maintenance) data to revise initial estimates of component characteristics. In particular, we will focus our attention on the initial ORLA estimates of maintenance factors and their actual values observed subsequent to the delivery of the first operational aircraft. This discussion applies to the problem of computing spares requirements after some early operational data are available.

The theory of Bayesian learning is well known. Its application to inventory systems has been discussed in [3], [7], [8], and other papers. The foundations of the theory may be found in [10]. The interested reader is referred to [9] for further discussion of the theory and applications.

Well in advance of the delivery of the first aircraft, estimates are made of component characteristics as part of the ORLA process. These initial estimates, including maintenance factors, are matters of substantial uncertainty. The theory of Bayesian learning suggests that it is constructive to characterize one's uncertainty about the true value of some unknown number by modeling it as a random variable with a probability distribution that best characterizes the uncertainty. This probability distribution is called the *a priori* probability distribution, or simply the *prior*.

Subsequent to the delivery of the first aircraft, data collected in the Air Force's maintenance data collection system are helpful in determining the true value of the maintenance factor. An important question concerns the

relative weights that should be given to those data and to the ORLA estimate. DoDI 4140.42 suggests a simple scheme for weighting the estimates and data as shown in Table 4-1.

TABLE 4-1. WEIGHTING FACTORS SUGGESTED BY DoDI 4140.42

Elapsed Time Since Preliminary Operational Capability	Weighting Factor: Initial Estimate	Weighting Factor: Operational Data*
6 Mos.	0.75	0.25
1 Yr.	0.50	0.50
18 Mos.	0.25	0.75
2 Yrs.	0.00	1.00

*These are specified as minimal values.

We have observed a strong tendency among logisticians to view early operational data as having little value. As we will show, such data have enormous utility in revising early estimates of maintenance factors; in fact, they may be dramatically more useful than most logisticians' intuition might suggest.

The theory of Bayesian learning specifies that the relative weighting of the initial estimate and the data is a function of the degree of uncertainty surrounding the estimate; i.e., the more uncertain the decision maker is about his estimate, the less weight it is given. Thus, Bayesian logic yields an optimal weighting of the estimate and the data in the sense that the weighting is consistent with the decision maker's uncertainty. In fact, however, no actual "decision maker" made any statements regarding his uncertainty about the F-16 estimated maintenance factors. The question we attempted to answer in this analysis was whether one could postulate various alternative models of uncertainty about the ORLA estimates and find one that was "best" in the sense that it yielded a relative weighting of the initial ORLA estimates and early operational data such that the revised estimates, when used by an availability model, resulted in a stockage posture that delivered the highest "actual"

availability for a specified investment level. By "actual" availability we mean the availability calculated for a stockage posture based on the actual maintenance factors observed during the last 24 months of the 30-month period covered by the CDS data (see Chapter 3). In other words, we used various amounts of data from the first six months to revise the ORLA estimates, computed alternative stockage postures using an availability model with various alternative weightings of the ORLA estimates and the data, then used data from the last 24 months to evaluate the stockage postures. The remainder of this chapter presents the results.

It is important in understanding this analysis to bear in mind the systematic positive bias in the ORLA estimates; they are, on the average, four times as large as the maintenance factors observed during the last 24 months of the 30-month period examined. The effects of this strong bias are seen throughout the results presented here.

THE ANALYSIS

This analysis examines three fundamental questions regarding the usefulness of early operational data in revising initial estimates of maintenance factors:

- What is the best probability model to use to characterize the uncertainty surrounding the initial estimate?
- What is the best technique to use to revise the initial estimate with observed data?
- How much operational experience is needed before revising the estimates?

The Probability Model

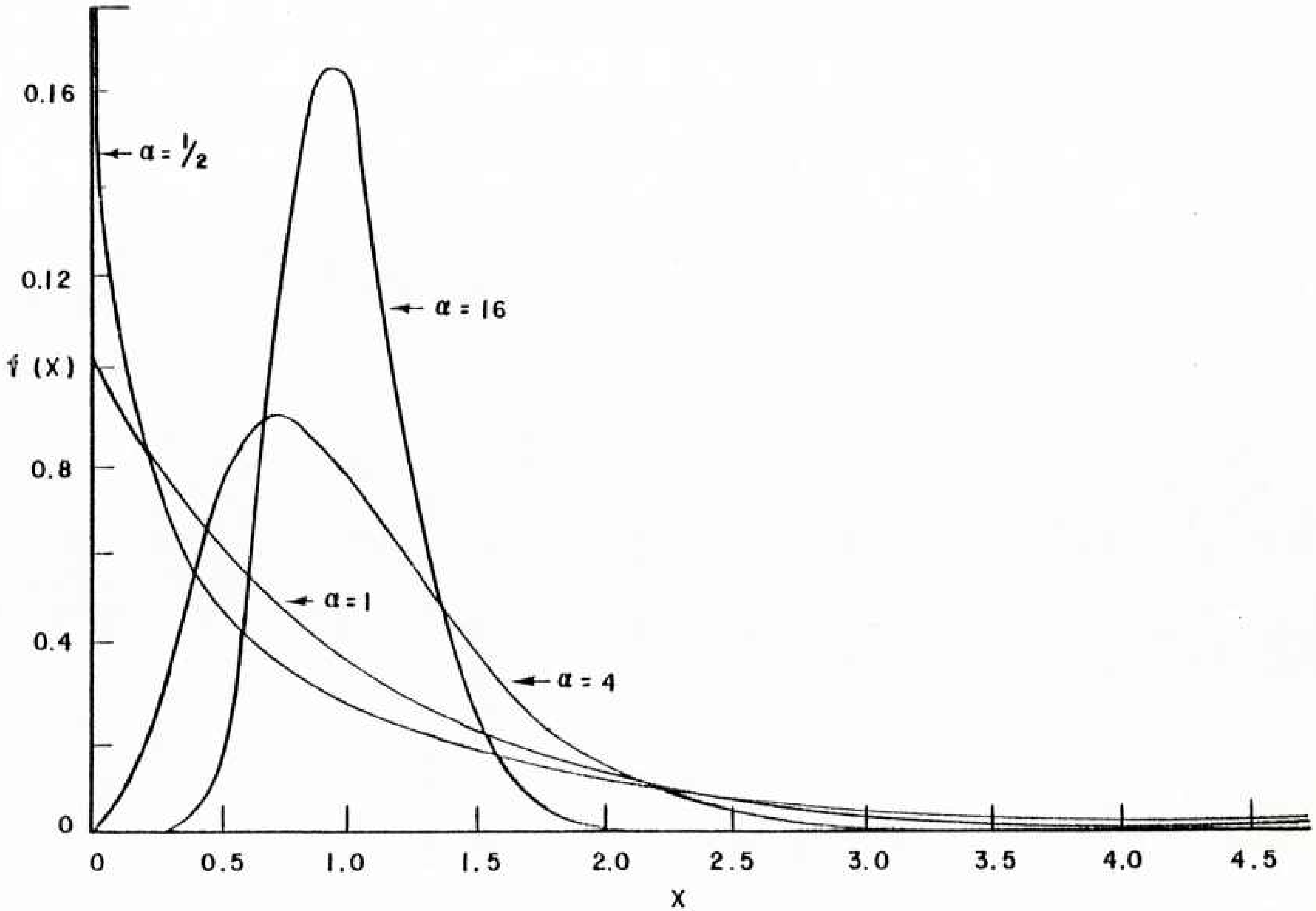
Because of its reasonableness, mathematical tractability, and other characteristics discussed in [10], we selected the gamma distribution as an

appropriate model of uncertainty, a choice widely reinforced by the literature. The gamma probability density function (p.d.f.) has the form

$$f(x) = \begin{cases} \dfrac{1}{\Gamma(\alpha)\beta^{\alpha}} \; x^{\alpha-1} \, e^{-x/\beta}, & 0 < x < \infty \\ 0 \text{ elsewhere.} & \end{cases}$$

The parameters of this distribution are α and β. Its mean is equal to $\alpha\beta$ and its variance is equal to $\alpha\beta^2$; therefore, β is the variance-to-mean ratio. α is a shape parameter. The value of α (whether $\alpha < 1$, $\alpha = 1$, or $\alpha > 1$) determines the shape of the p.d.f. as shown in Figure 4-1. The first step in the analysis was to examine systematically alternative methods of determining the parameters. Since the mean is equal to $\alpha\beta$ and is fixed equal to the ORLA estimate, setting one parameter determines the value of the other. We tried constant values of α for all components, constant values of β for all components, and a couple of mixed strategies. For each individual case, we pooled six months of data (1 January 1979 - 30 June 1979) with the ORLA estimates in a manner consistent with the particular values of α and β being examined; computed an optimal stockage posture with VARI-METRIC for each of three different budget levels, using the revised estimates of the maintenance factors resulting from six months of data and the choice of α or β; and predicted the availabilities that would result. In this step, VARI-METRIC was used in its optimization mode to compute the least-cost mix of spares for each of the three levels of investment. Then we computed the "actual" availabilities for each of those stockage postures, again using VARI-METRIC, this time in an evaluative mode, based on the actual, observed maintenance factors that were recorded during the 24-month period from 1 July 1979 to 30 June 1981. The results are shown in Table 4-2 (p. 4-6). In each of the first seven cases, α is the same for all components. These results indicate that

FIGURE 4-1 THE EFFECTS OF THE SHAPE PARAMETER



the performance of a stockage posture computed under the conditions described can be expected to be best with a fairly broad model of uncertainty i.e., with α around 1.0. Note, too, that for values of α between 0.8 and 2.0, the "actual" availabilities are virtually indistinguishable.

Four other cases of interest are examined in Table 4-2. In the cases in which $\alpha = 1 + 10MF$ and $\alpha = 0.1 + 20MF$, neither α nor β are the same for all components. The average ORLA maintenance factor (MF) was 0.0852; therefore, the case in which $\alpha = 1 + 10MF$ involved average values of α and β of 1.852 and 0.046, respectively, and in the case in which $\alpha = 0.1 + 20MF$, the average α and β were 1.804 and 0.047, respectively. Although these average values appear quite close to each other, they may be misleading. Table 4-3 shows more clearly how different the two cases are. The case in which $\alpha = 0.1 + 20MF$ yields a substantially more heterogeneous mix of values of α.

The last two cases in Table 4-2 involve fixed values of β for all components. The case in which $\alpha = 50MF$ results in a value of $\beta = 0.02$, and where $\alpha = 100MF$, $\beta = 0.01$. The resultant average values of α for these two cases are 4.26 and 8.52, respectively.

TABLE 4-2. PREDICTED VS. "ACTUAL" AVAILABILITIES FOR SEVERAL ALTERNATIVE VALUES OF α USING BAYESIAN REVISION AND SIX MONTHS OF DATA

	\$20M		\$30M		\$40M	
α	Pred	Act	Pred	Act	Pred	Act
0.5	41.98	70.67	68.41	88.23	86.59	95.43
0.8	39.99	72.95	67.48	89.53	86.58	96.15
1.0	39.29	72.94	66.89	89.83	86.64	95.89
1.5	37.71	73.10	66.26	89.89	86.95	95.40
2.0	36.62	73.01	65.80	89.86	87.18	95.59
5.0	33.50	70.22	64.90	87.88	88.13	93.22
10.0	31.47	66.61	64.47	86.43	88.97	92.64
1 + 10MF	28.99	71.06	59.18	89.55	83.77	96.46
0.1 + 20MF	23.93	69.58	53.57	88.68	74.36	97.93
50MF	22.12	64.69	54.24	86.29	82.00	96.65
100MF	22.75	61.16	57.15	83.92	85.57	95.21

TABLE 4-3. BEHAVIOR OF THE SHAPE PARAMETER AS A FUNCTION OF THE MAINTENANCE FACTOR

ITEM	RESULTANT VALUE OF α	
MF	$\alpha = 1 + 10MF$	$\alpha = 0.1 + 20MF$
0.005	1.05	0.2
0.05	1.5	1.1
0.5	6.0	10.1

The stockage postures in each of the last four cases in Table 4-2 perform relatively more poorly at lower budget levels than those involving fixed values of α between 0.8 and 2.0; moreover, the predicted availabilities are even worse estimates of the "actual" availabilities than in the fixed-alpha cases.

For these F-16 data, we would choose $\alpha = 1$. This value places little weight on the ORLA estimates relative to the observed data because it represents relatively great uncertainty about the estimates. It is not clear that $\alpha = 1$ is universally the best choice for all initial provisioning problems, but it seems to us a reasonable one. Given our experience with initial provisioning data we have examined from other weapon systems, we believe that the poor quality of provisioning data is best characterized by a fairly broad model of uncertainty surrounding initial estimates of component characteristics. Although one might find probability models involving a shape parameter that is a function of the maintenance factor that could do somewhat better given these data, we are doubtful about the robustness of such models when applied to other initial provisioning problems. Furthermore, the accuracy of the estimated availabilities is also a matter of importance in choosing parameters.

As Table 4-2 illustrates, the Bayesian strategy applied to the F-16 data results in estimated availabilities that are lower than the "actual"

availabilities in every single case. Since the predictive capability of an availability model is obviously of concern in the initial provisioning problem, we were motivated to examine techniques other than the classical Bayesian approach for revising early estimates.

The Revision Technique

As we pointed out previously, the F-16 ORLA estimates were very heavily biased. Of the 810 ORLA estimates examined in this study, 721 were higher than the actual maintenance factors observed during the 30-month period covered by the CDS data. Only 89 of the estimates erred in the other direction. This systematic bias led us to consider alternative strategies for revising the initial estimates. Three of those strategies involve the use of a linear correction factor. One of these also involves partitioning the set of components into two subsets (one consisting of the components of the fire control and weapons delivery systems). The fourth strategy was the method prescribed by DoDI 4140.42. Table 4-4 compares the performances of these four strategies, again with six months of data, at the \$20, \$30, and \$40 million levels of investment. It also presents the results of the Bayesian strategy for $\alpha = 1$, shown in Table 4-2. (We used $\alpha = 1$ for the other strategies as well, except for the DoDI 4140.42 method to which it is not applicable.)

TABLE 4-4. EVALUATION OF ALTERNATIVE REVISION TECHNIQUES

Revision Technique	Availabilities By Budget Level: \$20M Pred	\$20M Act	\$30M Pred	\$30M Act	\$40M Pred	\$40M Act
DoDI 4140.42	25.40	61.92	63.28	84.11	90.99	93.79
LIN-BAYES	66.45	72.03	89.20	85.93	97.39	93.41
BAYES-LIN	71.01	77.26	91.36	91.15	98.03	96.60
BAYES-LIN(S)	65.71	70.85	88.57	84.46	97.09	92.11
BAYES	39.29	72.94	66.89	89.83	86.64	95.89

The method prescribed by DoDI 4140.42 consists of assigning a weight of 0.25 (DoDI 4140.42 specifies 0.25 as a minimal value) to the six months of observed data. Although it is clearly dominated by each of the other methods examined here, it does surprisingly well given its simplistic nature; in fact, its performance in both predicted and "actual" availabilities is within the range of policies examined in Table 4-2 involving a purely Bayesian strategy.

The method labeled LIN-BAYES consists of multiplying every ORLA estimate by a correction factor equal to

$$\sum_{i=1}^{n} M_i \Big/ \sum_{i=1}^{n} \hat{M}_i$$

where $\hat{M}_i$ = the ORLA estimated maintenance factor of component i, M_i = the observed maintenance factor in the six-month period, and n = 810; the resulting value is then subjected to Bayesian revision. The original probability model is changed by multiplying its second parameter, β (the variance-to-mean ratio), by the correction factor.

The BAYES-LIN method, as one might guess, performs the Bayesian revision first, and then modifies the revised estimate by the correction factor which, in this case, is equal to

$$\sum_{i=1}^{n} M_i \Big/ \sum_{i=1}^{n} M_i'$$

where M_i' = the mean of the revised probability distribution of the maintenance factor of component i after the Bayesian update. Again, the multiplication is performed on the variance-to-mean ratio.

The BAYES-LIN(S) method is simply the BAYES-LIN method applied separately to the data from the fire control and weapons delivery systems and the data from all the other systems. The partitioning was not helpful.

The BAYES-LIN method clearly and dramatically dominates every other method, both in its "actual" availabilities at every budget level and in its substantially better predictive accuracy. The rationalization for the use of the correction factor lies not only in its superior performance, but also in the fact that, when initial estimates are so strongly and systematically biased (as they are in the F-16 case), it uses information gained from all components to correct the estimate for each individual component. Furthermore, if the initial estimates are subject only to random error rather than the strong bias observed here, then the correction factor will be close to unity and will have no effect; i.e., the BAYES-LIN method will be virtually the same as a pure, Bayesian strategy.

A remaining question regarding the BAYES-LIN strategy was whether it performed well for values of alpha other than unity. Table 4-5 (p. 4-14) reproduces the data of Table 4-2 and compares them with the same data for the BAYES-LIN method. The data show that the performance of the method has essentially the same sensitivity to the value of alpha as the Bayesian technique exhibits. Thus, our choice of $\alpha = 1$ is reinforced.

When To Revise

Thus far we have examined revision of initial estimates only with six months of operational data. In the F-16 case, six months corresponds to 963.5 flying hours. The last of the three fundamental questions we examine here is, "How much operational experience is needed before revising the estimates?" The answer to this question is, "Astonishingly little!" We believe it is constructive at this point to digress for a moment and relate a story told by Professor Howard Raiffa [14:20-21]. We quote verbatim.

> "Professor Ward Edwards, a psychologist at the (sic) University of Michigan, has investigated the intuitive reactions of many subjects to experimental, probabilistic evidence. In one of his experiments he poses the following problem.

> 'I have two canvas book bags filled with poker chips. The first bag contains 70 green chips and 30 white chips, and I shall refer to this as the predominantly green bag. The second bag contains 70 white chips and 30 green chips, and I shall refer to this as the predominantly white bag. The chips are all identical except for color. I now mix up the two bags so that you don't know which is which, and put one of them aside. I shall be concerned with your judgments about whether the remaining bag is predominantly green or not. Now suppose that you choose 12 chips at random with replacement from this remaining bag and it turns out that you draw eight green chips and four white chips, in some particular order. What do you think the odds are that the bag you have sampled from is predominantly green?'

At a cocktail party a few years ago I asked a group of lawyers, who were discussing the interpretation of probabilistic evidence, what they would answer as subjects in Edwards' experiment. First of all, they wanted to know whether there was any malice aforethought in the actions of the experimenter. I assured them of the neutrality of the experimenter, and told them that it would be appropriate to assign a .5 chance to 'predominantly green' before any sampling took place.

'In this case,' one lawyer exclaimed after thinking awhile, 'I would bet the unknown bag is predominantly white.'

'No, you don't understand,' one of his colleagues retorted, 'you have drawn eight greens and four whites from this bag. Not the other way around.'

'Yes, I understand, but in my experience at the bar, life is just plain perverse, and I would still bet on predominantly white! But I really am not a betting man.'

The other lawyers all agreed that this was not a very rational thing to do - that the evidence was in favor of the bag's being predominantly green.

'But by how much?' I persisted. After a while a consensus emerged: The evidence is meager; the odds might go up from 50-50 to 55-45; but '...as lawyers we are trained to be skeptical, so we would slant our best judgments downward and act as if the odds were still roughly 50-50.'

The answer to the question 'By how much?' can be computed in a straight-forward fashion (we do it below), and there is no controversy about the answer. The probability that the bag is predominantly green, given a sample of eight green and four white chips, is .964. Yes, .964. This bag is predominantly green 'beyond a reasonable doubt.' This story points out the fact that most subjects vastly underestimate the power of a

small sample. The lawyers described above had an extreme reaction, but even my statistics students clustered their guesses around .70.

The analysis goes this way: Let us denote the predominantly green and white bags by GB and WB, respectively. We then have P(GB) = .5 and P(WB) = .5. Let A stand for the event 'eight greens and four whites, in the particular order g g w g w g g w g w g g'. (The particular order is actually unimportant; we give this example only for the sake of concreteness.) We then have

$$P(A|GB) = .7 \times .7 \times .3 \times \ldots \times .7 = (.7)^8(.3)^4,$$

$$P(A|WB) = .3 \times .3 \times .7 \times \ldots \times .3 = (.7)^4(.3)^8.$$

Now from Bayes' Theorem, with GB in place of θ_1, WB in place of θ_2, and A in place of R) (sic), we have

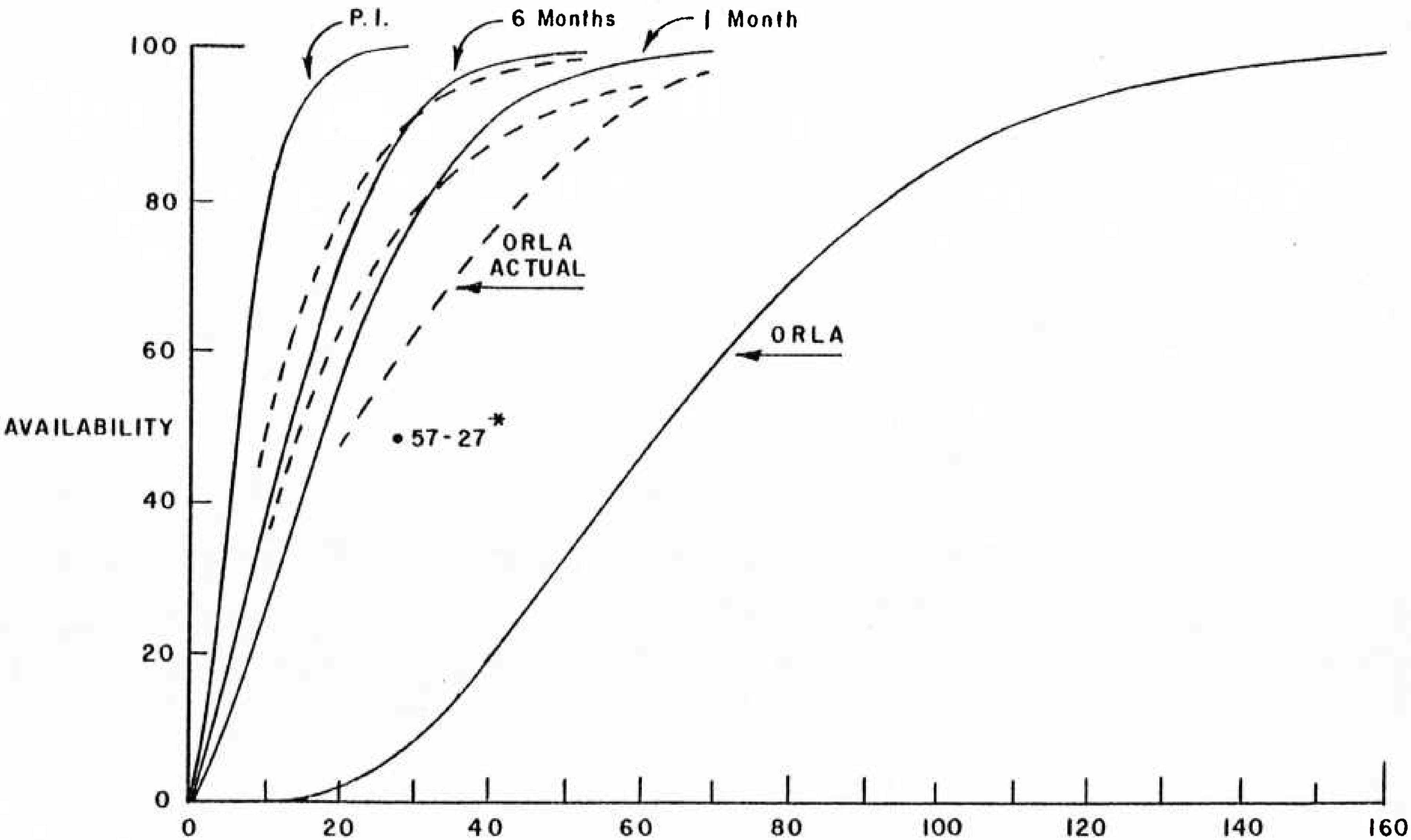
$$P(GB|A) = \frac{P(A|GB)P(GB)}{P(A|GB)P(GB) + P(A|WB)P(WB)}$$

$$= \frac{(.7)^8(.3)^4(.5)}{(.7)^8(.3)^4(.5) + (.3)^8(.7)^4(.5)} = .964 \text{ ."}$$

Edwards calls the tendency of human subjects to resist changing their a priori judgments of probabilities the conservatism effect. It is the conservatism effect that tends to induce reluctance in people to place sufficient value on observed data. We believe this anecdote to be especially pertinent to the initial provisioning problem.

Figure 4-2 shows four availability-vs.-cost curves (predicted availabilities), one based on the ORLA estimates, one based on estimates revised with only one month of data (42.9 flying hours), one based on estimates revised after six months (963.5 flying hours), and one based on "perfect information," i.e., based on the CDS data for the 24-month period from 1 July 1979 to 30 June 1981. The dashed lines in Figure 4-2 portray "actual" availabilities. The changes in the predicted curves essentially reflect the cost of uncertainty. Note the very large predictive error of the ORLA curve

FIGURE 4-2 IMPROVEMENTS IN AVAILABILITY vs COST USING BAYES-LIN



* COST = 28.1, AVAILABILITY = 48

TABLE 4-5. COMPARISON OF BAYES VS. BAYES-LIN REVISION TECHNIQUES

BAYESIAN, 6 MOS

α	$20M Pred	$20M Act	$30M Pred	$30M Act	$40M Pred	$40M Act
0.5	41.98	70.67	68.41	88.23	86.59	95.43
0.8	39.99	72.95	67.48	89.53	86.58	96.15
1.0	39.29	72.94	66.89	89.83	86.64	95.89
1.5	37.71	73.10	66.26	89.89	86.95	95.40
2.0	36.62	73.01	65.80	89.86	87.18	95.59
5.0	33.50	70.22	64.90	87.88	88.13	93.22
10.0	31.47	66.61	64.47	86.43	88.97	92.64
1 + 10MF	28.99	71.06	59.18	89.55	83.77	96.46
0.1 + 20MF	23.93	69.58	53.57	88.68	74.36	97.93
50MF	22.12	64.69	54.24	86.29	82.00	96.65
100MF	22.75	61.16	57.15	83.92	85.57	95.21

BAYES-LIN, 6 MOS

α	$20M Pred	$20M Act	$30M Pred	$30M Act	$40M Pred	$40M Act
0.5	64.43	75.16	86.96	89.82	96.10	96.94
0.8	68.84	77.24	89.97	90.50	97.48	96.58
1.0	71.01	77.26	91.36	91.15	98.03	96.60
1.5	74.79	76.93	93.61	90.45	98.74	96.18
2.0	77.42	76.79	94.99	90.09	99.08	95.26
5.0	84.55	74.58	97.76	88.45	99.51	91.83
1 + 10MF	81.85	75.83	96.84	91.86	99.38	96.00
0.1 + 20MF	81.63	77.66	96.69	93.24	99.33	98.03
50MF	87.57	73.73	98.50	90.25	100.00	94.93*
100MF	90.49	70.83	99.07	87.17	100.00	90.05**

*$39.16M
**$36.50M

induced by the bias in the ORLA estimates. Note, too, the dramatic improvement in availability-vs.-cost when only one month of experience is used to revise the ORLA estimates as well as the remarkable improvement in predictive accuracy. After six months of experience, the availability-vs.-cost curve moves substantially closer to the "perfect" curve. The conservatism effect might lead one to feel that the effectiveness of probability revision based on so few data is counterintuitive but the results speak for themselves.

The lesson here is clear and compelling. If there ever is need to compute spares requirements in a weapon-system acquisition program when operational data are available, however sparse, one should revise initial estimates prior to the computation. The Bayesian method explicitly accounts for the paucity of data in the methodology used in the revision. It is a powerful technique and should be used whenever any operational data are available.

5. CONCLUSIONS AND RECOMMENDATIONS

Several important conclusions emerge from this analysis. In this final chapter, we present those conclusions, suggest ways in which the DoD can move toward improved initial provisioning strategies, and recommend actions that we believe would enhance the cost-effectiveness of initial provisioning throughout the DoD.

CONCLUSIONS

This work focused on four issues involved in a spares acquisition strategy: (1) estimation of component characteristics, (2) determination of spares investment levels, (3) computation of spares requirements, and (4) usefulness of early operational data in revising initial estimates of component characteristics. The F-16 case provides statistical evidence on each of these issues.

Estimation of Component Characteristics

We examined estimates of maintenance factors and unit costs for the F-16 and compared those estimates with observed values. We found that maintenance factor estimates for 810 recoverable components peculiar to the F-16 were high and unit cost estimates were remarkably accurate on a random sample of 20 SAIP items.

In retrospect, we think that the pessimistic maintenance factors reflect the natural human tendency of logisticians who had full knowledge of the use to which they would ultimately be put, i.e., as a basis for spares requirements computations. It was clear to us that the Air Force personnel who made the initial ORLA estimates made a careful, thorough, and conscientious effort to make sound judgments based on past experience, similar

applications, contractors' estimates, and other factors. However, we suspect that a logistician's tendency in that situation, given the uncertainty and the consequences involved, would be to make the estimates of maintenance factors on the high side, to avoid the outcome of providing inadequate logistics support to the weapon system. Thus, we have little more to say about the ORLA estimates except that we judge that they were made in good faith on the best data available at the time.

We cannot generalize or extend to other weapon systems our observations about the powerful bias in the F-16 initial estimates or the remarkably accurate unit costs we observed on the 20 randomly selected SAIP items. However, our observations (see Chapter 2) about some of the anomalies in the maintenance data and the sources of error in assigning maintenance factors to higher assemblies certainly apply to any initial provisioning problem.

Determination of Spares Investment Levels

In a previous report [1], we concluded that an availability model would be useful in determining the appropriate spares investment level for a new weapon system provided only that component-level data were available, even if those data were only estimates. We reasoned that the availability-vs.-cost curve computed by an availability model enabled the investment level decision to be made in full light of the weapon-system availability that would result from any specified investment level. In the F-16 case, most of the component-level data were not available until at least a year after the initial spares investment decision was made. Moreover, the F-16 program is typical of many weapon-system programs in this sense. However, investment-level decisions typically have to be made to size the initial spares packages to be procured for support of additional deployments of the weapon system in subsequent years, especially for large programs. The initial F-16 data, when used by an

availability model, VARI-METRIC, under conditions we viewed as reasonable and defensible, resulted in an availability-vs.-cost curve that would have overstated the required investment. The cause, as we have pointed out, does not lie in the algebra of the model but in the strong, systematic, positive bias in the F-16 ORLA estimates of the component maintenance factors. As we showed in Chapter 3, the initial failure-factor estimates, when viewed at an aggregate level, were clearly inconsistent with MTBF goals for the F-16. We conclude, therefore, that when an availability-vs.-cost curve is supported by initial estimates alone, as much other information as may be available should be used in conjunction with the availability-vs.-cost curve in reaching the investment decision. Furthermore, if there are operational data available, we would argue that the use of an availability model, supported by initial estimates <u>modified by the operational data</u>, would be preferable to any other strategy for determining the investment level.

<u>Computation of Spares Requirements</u>

Given a specified investment level, it is clear how best to compute spares requirements. The availability model provides a stockage posture that is clearly superior both in its performance (availability delivered) and its greater immunity to uncertainty.

This study has reinforced our observations in [1] on this issue. For any level of investment, VARI-METRIC (and certain other spares optimization models), with the specification of a fairly broad prior ($\alpha = 1$, say) by the user, will compute a spares posture that will deliver substantially greater weapon-system availability than will a stockage posture computed in accordance with AFLCR 57-27. Furthermore, the optimized stockage posture will be more robust in the face of uncertainty. This robustness is especially important in the initial provisioning scenario where early estimates of component characteristics are often poor.

Usefulness of Early Operational Data

We conclude that early operational data are dramatically more useful in revising initial estimates of maintenance factors than one's intuition might suggest. Postponing revisions until the end of the demand development period is an especially serious mistake because any spares requirements computations made during that period to support future deployments could lead to significant over- or underinvestment and to procurements of the wrong mixes of spares.

The weighting factors prescribed by DoDI 4140.42, although defined as minimal values, result in stockage postures that are clearly inferior to those computed using a Bayesian or "BAYES-LIN" strategy (p. 4-8). Furthermore, the strategy of giving full weight to the data and no weight to the initial estimates after the first two years is a mistake, in part because it assigns failure rates of zero to items that happened not to fail during the first two years.

After evaluating several revision strategies, we conclude that a linear correction factor, applied after the Bayesian revision, significantly improves the resultant set of estimates (p. 4-9). We refer to this method as "BAYES-LIN." It not only provides the best estimates of availability, but also produces the highest availability for a specified level of investment.

RECOMMENDATIONS

We recommend that the ASD(MRA&L):

a. Revise DoDI 4140.42 to require the use of availability models to compute initial spares requirements given a specified level of investment.

b. Evaluate the "BAYES-LIN" revision strategy on another weapon-system acquisition program. If it again dominates other strategies, then:

   - Require the use of the "BAYES-LIN" strategy on future systems.

   - Delete the weighting factors prescribed by DoDI 4140.42.

APPENDIX A. THE VARI-METRIC MODEL

The VARI-METRIC Model is a multi-echelon inventory model. Component failures are modeled as a simple Poisson process whose mean is a random variable which is distributed according to a gamma distribution. VARI-METRIC is similar to other multi-echelon inventory models, including the Air Force's MOD-METRIC Model, the Army's SESAME Model and LMI's Aircraft Availability Model. It calculates availability by computing the expected backorders (EBOs) for each component based on its asset position. The essential difference in VARI-METRIC is that it takes explicit consideration of uncertainty by assigning a gamma prior to the initial estimates of component failure rates. Furthermore, it considers the correlation between demands and the average depot resupply time due to the gamma prior.

A listing of the VARI-METRIC Model is provided here.

```
C ** ** LA61A/STARS/SOURCE/IP/2BMAIN01
C
C THIS PROGRAM USES THE FOLLOWING SUBROUTINES UNDER LA61A/LMILIB
C   LUMPDGVM
C   BINITGVM
C   DLNGAMMA
C   DFACTLN
C******************************************************************
C
C**** THIS VERSION OF VARI-METRIC IS SPECIFICALLY DESIGNED TO MODEL
C         A TWO ECHELON RESUPPLY SYSTEM WITH 1 DEPOT AND 2 BASES.
C         IT EXPLICITLY CONSIDERS THE FACT THAT THE 2 BASES ARE NOT
C         IDENTICAL.  THE MODEL OUTPUTS A CURVE OF COST VS. AVAILABILITY
C         AND A FILE WITH THE DATA NECCESSARY TO PRODUCE A COMPONENT
C         SHOPPING LIST FOR ANY POINT ON THE COST/AVAILABILITY CURVE.
C         THE AVAILABILITY IS PEACETIME AVAILABILITY FOR THE MD OF
C         INTEREST.  THIS IS A WEIGHTED AVERAGE OVER ALL THE MDS'S.
C         THE MODEL CAN HANDLE ANY # OF MDS'S BY INCREASING MAXMDSS.
      PARAMETER MAXEBO=1500,MAXMDSS=2,MAXMDSX2=4,MXMONTHS=25
C**** COMPILER WON'T PERMIT USING PARAMETER MAXMDSS IN FORMAT 750.
      COMMON/EBO/EBO0,EBO(MAXEBO),SV0,SV(MAXEBO),NDOUT0,NDOUT(MAXEBO)
      REAL BSHARE(2),BPIPE(2),Q(2),QM1OVERQ(2),PIPEOVRQ(2)
      REAL BEBO(2),REBO(2),TERM(2),PCTNAIR(MAXMDSS)
      REAL UHK(MAXMDSS),FLHRLAST(MAXMDSX2),RNAIRLST(MAXMDSX2)
      REAL GLCOST(MAXEBO)
      REAL TFLHRS(MAXMDSS),TNAIR(MAXMDSS),THISTFLH(MAXMDSS)
      REAL RNAIR(MXMONTHS,MAXMDSX2),FLHRS(MXMONTHS,MAXMDSX2)
      INTEGER NB(2),IQPA(MAXMDSS),NRECS(MAXMDSX2)
      INTEGER JBASE(MAXMDSX2),KFIRST(MAXMDSX2),IGLQTY(MAXEBO)
      CHARACTER DATE*5,STARTDAT*5,STOPDATE*9,MD*4,MDOFINT*4
      CHARACTER MDS*7(MAXMDSX2),WUC*8,PN*20,SMR*7
      LOGICAL DEBUG
C
      SV0=1.E8
C
C
C
C
C
C
C*********************************************************************
C******************************************************************
C**** BEGIN RUN.  READ IN DATA ON THE # OF A/C AND THE FLYING
C****   HOURS AT EACH BASE FOR EACH MDS.
C****   K IS AN INDEX FOR MDS AND BASE.  FOR EXAMPLE FOR 2 MDSS
C****   AND TWO BASES, K WILL RANGE FROM 1 TO 4.  K=1&2 WILL BE FOR THE
C****   FIRST MDS AND 3&4 WILL BE FOR THE SECOND.  KFIRST(IMDS) IS
C****   THEFIRST K FOR A PARTICULAR MDS ( THE LAST WOULD BE
C****   KFIRST(IMDS+1)-1 .
C**** MDS(K) & JBASE(K) DEFINE THE MDS,BASE COMBINATION REPRESENTED BY
C****   RNAIR(I,K) & FLHRS(I,K) ARE THE # A/C & FLYING HOURS FOR MDS/BSAE K
C****   DURRING MONTH I.  RNAIRLST(K) IS THE # A/C FOR THE LAST MONTH FOR K.
C****   TFLHRS(IMDS) &TNAIR(IMDS) ARE THE TOTAL (SUMMED OVER THE BASES)
C****   FLYING HOURS & # A/C FOR THE LAST MONTH.  THISTFLH(IMDS) IS ALSO SUMMED
C****   OVER TIME (THE TOTAL HISTORICAL FLYING HOURS).
      READ(5,1)MDOFINT,STARTDAT,STOPDATE
    1 FORMAT(V)
      DECODE(STARTDAT,2)MONTHST,IYRSTART
    2 FORMAT(I2,1X,I2)
      K=1
      NMDSS=1
      KFIRST(1)=1
      TFLHRS(1)=0.
      TNAIR(1)=0.
```

```
      THISTFLH(1)=0.
      READ(4,1)LINENO,MD,MDS(1),JBASE(1),NRECS(1)
      GO TO 25
   10 FLHRLAST(K)=FLHRS(ISTART-1+NRECS(K),K)
      TFLHRS(NMDSS)=TFLHRS(NMDSS)+FLHRLAST(K)
      RNAIRLST(K)=RNAIR(ISTART-1+NRECS(K),K)
      TNAIR(NMDSS)=TNAIR(NMDSS)+RNAIRLST(K)
      TOTALAC=TOTALAC+RNAIRLST(K)
      K=K+1
      READ(4,1,END=89)LINENO,MD,MDS(K),JBASE(K),NRECS(K)
      IF(MDS(K).EQ.MDS(K-1))GO TO 25
      NMDSS=NMDSS+1
      KFIRST(NMDSS)=K
      TFLHRS(NMDSS)=0.
      TNAIR(NMDSS)=0.
      THISTFLH(NMDSS)=0.
   25 IF(MD.NE.MDOFINT)STOP " BAD MD"
      READ(4,1)LINENO,DATE,TEMPNAIR,TEMPFLHR
      DECODE(DATE,2)MONTH,IYR
      ISTART=1+MONTH-MONTHST+12*(IYR-IYRSTART)
      RNAIR(ISTART,K)=TEMPNAIR
      FLHRS(ISTART,K)=TEMPFLHR
      THISTFLH(NMDSS)=THISTFLH(NMDSS)+TEMPFLHR
      IF(NRECS(K).EQ.1)GO TO 10
      DO 80 I=ISTART+1,ISTART-1+NRECS(K)
         READ(4,1)LINENO,DATE,RNAIR(I,K),FLHRS(I,K)
         THISTFLH(NMDSS)=THISTFLH(NMDSS)+FLHRS(I,K)
   80 CONTINUE
      GO TO 10
   89 KFIRST(NMDSS+1)=K
C
      DO 90 IMDS=1,NMDSS
         PCTNAIR(IMDS)=TNAIR(IMDS)/TOTALAC
   90 CONTINUE
      DO 95 I=1,NMDSS
         WRITE(6,92)MDS(KFIRST(I)),TNAIR(I),TFLHRS(I),THISTFLH(I)
   92    FORMAT(" MDS,TNAIR,TFLHRS,THISTFLH= ",A7,3F8.0)
   95 CONTINUE
C
C
      BRT=6.
      OST=14.
      DRT=56.
C
C**** THE ALPHA PARAMETER OF THE GAMMA PROIR FOR A PARTICULAR
C       COMPONENT, IS GIVEN BY;
C
C              ALPHA=CONSTA+CONSTB*FF
C
C      WHERE,
C                   FF IS THE COMPONENT FAILURE FACTOR.
C
C**** READ CONSTA & CONSTB
      READ(5,1)CONSTA,CONSTB
C
C
C
C
C
C
C*****************************************************************
C**************************************************************
C**** BEGIN NEW COMPONENT.  READ COMPONENT CHARACTERISTICS.
  100 READ(11,1,END=999)WUC,PN,SMR,COST,FF,IQPA,BNRTS,CONPCT,PLT
      NREADS=NREADS+1
      DEBUG=.F.
```

```
      ALPHA=CONSTA+CONSTB*FF
C
C**** COMPUTE PIPELINES AND PRORATING FACTORS.
      DRPCT=BNRTS*(1-CONPCT)
      BRPCT=1.-BNRTS
      IF(BNRTS.LE.0.)BRPCT=1.-CONPCT
      TCONPCT=1.-DRPCT-BRPCT
      BSHARE(1)=0.
      BSHARE(2)=0.
      RIP=0.
      TI=0.
      RIPHIST=0.
C
      DO 140 IMDS=1,NMDSS
C
         DO 120 K=KFIRST(IMDS),KFIRST(IMDS+1)-1
            RIPT=FLHRLAST(K)*IQPA(IMDS)
            RIP=RIP+RIPT
            BSHARE(JBASE(K))=BSHARE(JBASE(K))+RIPT
            TI=TI+RNAIRLST(K)*IQPA(IMDS)
  120    CONTINUE
C
C**** RIPHIST IS THE TOTAL HISTORICAL COMP. FLYING HRS,  USED IN NEGAS COMP.
      RIPHIST=RIPHIST+THISTFLH(IMDS)*IQPA(IMDS)
  140 CONTINUE
C
C**** UHK IS A COMMON COMPONENT PRORATING TERM.  SEE T.J. O'MALLEY'S PAPER
C****   ON COMMON COMPONENTS FOR AN EXPLANATION.
      DO 150 IMDS=1,NMDSS
         UHK(IMDS)=TFLHRS(IMDS)*TI/(RIP*TNAIR(IMDS))
  150 CONTINUE
C
      BSHARE(1)=BSHARE(1)/RIP
      BSHARE(2)=BSHARE(2)/RIP
      IF(DEBUG)WRITE(6,160)BSHARE
  160 FORMAT("  BSHARE= ",2F8.4)
      TLAMBDA=RIP*FF/3000.
C**** NEGAS IS THE NEGATIVE ASSET POSITION CAUSED BY CONDEMNATIONS
C****   DURRING THE INITIAL PROVISIONING PERIOD.
      NEGAS=FF*RIPHIST*TCONPCT*.01+.5
      BRPIPE=TLAMBDA*BRPCT*BRT
      DRPIPE=TLAMBDA*DRPCT*DRT
      CONPIPE=TLAMBDA*TCONPCT*PLT*30.
      DPIPE=DRPIPE+CONPIPE
      OSPIPE=TLAMBDA*(DRPCT+TCONPCT)*OST
      BOPIPE=OSPIPE+BRPIPE
      IF(DEBUG)WRITE(6,170)BRPIPE,DRPIPE,CONPIPE,OSPIPE,ALPHA
  170 FORMAT("  BRPIPE,DRPIPE,CONPIPE,OSPIPE,ALPHA=",5F10.3)
C
C
C
C****************************************************************
C**** BEGIN MARGINAL ANALYSIS.  THE NUMBER OF SPARES AT THE DEPOT
C****   (ND) IS THE OUTER LOOP.  THE NUMBER OF SPARES AT THE BASES
C****   (NB) IS THE INNER LOOP.  NTOT IS THE TOTAL # OF MARGINAL
C****   SPARES ALLOCATED.  LUMPD IS THE NUMBER OF SACROSANCT SPARES
C****   ALLOCATED (ALL TO THE DEPOT).  FOR A PARTICULAR NTOT, THE ND,NB
C****   COMBINATION WITH THE LOWEST TOTAL EBO IS SAVED IN THE EBO
C****   AND NDOUT ARRAYS.
C
C**** INITIALIZE DEPOT, COMPUTING LUMPD, DEPOTCF, AND DEBO VARIABLES.
      CALL LUMPDGVM(DPIPE,ALPHA
     & ,LUMPD,DEBO,DREBO,DTERM,DEPOTM2,DEPOTCF,DQM1OVRQ,DPIPOVRQ)
C
C**** START ND LOOP.
      TSUNKL=TSUNKL+COST*LUMPD
```

```
      TSUNKN=TSUNKN+COST*NEGAS
      ND=LUMPD
      CALL SPRAY(99999.,EBOO,1+NEBOS)
      NEBOS=0
C
C   ==== INITIALIZE BASE RESUPPLY PDF
  200     DO 220 I=1,2
C
             CALL BINITGVM(DEBO,DEPOTM2,DEPOTCF,BSHARE(I),BOPIPE
     &        ,ALPHA,BPIPE(I),Q(I),QM1OVERQ(I),PIPEOVRQ(I)
     &        ,BEBO(I),REBO(I),TERM(I))
C         ---- NON-UNIFORM BASE MOD
             BEBO(I)=BEBO(I)*BSHARE(I)
C
  220     CONTINUE
C
C   ==== FOR ALL REASONABLE NTOT'S COMPUTE EBO AND PRINT
          NB(1)=0
          NB(2)=0
          EBOTEMP=BEBO(1)+BEBO(2)
          NTOT=ND-LUMPD
          IF(EBOTEMP.GE.EBO(NTOT))GO TO 400
          EBO(NTOT)=EBOTEMP
          IF(NTOT.GT.NEBOS)NEBOS=NTOT
          NDOUT(NTOT)=ND
  400     IWIN=1
          IF(REBO(2).GT.REBO(1))IWIN=2
C*    === ADD A SPARE TO NWIN, DECREMENT EBOTEMP AND UPDATE EBO AS NECC.
C*    ===   ALSO UBDATE REBO AND TERM AT IWIN.
          REBOTEMP=REBO(IWIN)
          IF(REBOTEMP.LT.1.E-4)GO TO 500
          NB(IWIN)=NB(IWIN)+1
          NTOT=NTOT+1
          BEBO(IWIN)=BEBO(IWIN)-REBOTEMP
          EBOTEMP=EBOTEMP-REBOTEMP
          IF(EBOTEMP.GE.EBO(NTOT))GO TO 450
          EBO(NTOT)=EBOTEMP
          IF(NTOT.GT.NEBOS)NEBOS=NTOT
          NDOUT(NTOT)=ND
  450     N=NB(IWIN)
          TERM(IWIN)=TERM(IWIN)*(PIPEOVRQ(IWIN)+QM1OVERQ(IWIN)*(N-1))/N
          REBO(IWIN)=REBO(IWIN)-TERM(IWIN)
C
C*    === IF(EBO ARRAY NOT FULL CONTINUE ADDING SPARES.
          IF(NTOT.LT.MAXEBO)GO TO 400
          DEBUG=.T.
C
C**** IF DREBO NOT EXHAUSTED, INCREMENT ND UPDATE DEBO, ETC. & CONTINUE
  500 IF(DREBO.LT.1.E-4)GO TO 600
      DEBO=DEBO-DREBO
      DEPOTM2=DEPOTM2-DEBO-DEBO-DREBO
      DTERM=DTERM*(DPIPOVRQ+DQM1OVRQ*ND)/(ND+1)
      DREBO=DREBO-DTERM
      ND=ND+1
      IF(ND-LUMPD.LE.MAXEBO)GO TO 200
      WRITE(6,1)" ND EXIT ON ",WUC
C
C
C
C**********************************************************************
C**** COMPUTE CONVEX AVAILABILITY VS. DOLLARS.
  600 QSLOG=0.
      QNLOG=0.
      NSVS=0
C**** FIND IESTART (WHERE AVAILABILITY IS > 0.).
      IESTART=0
```

```
      IF(EBOO.LE.TI)GO TO 610
      DO 605 IESTART=1,NEBOS
         IF(EBO(IESTART).LE.TI)GO TO 610
  605 CONTINUE
  610 TSUNKIE=TSUNKIE+IESTART*COST
C
C**** COMPUTE STARTING AVAILABILITY.
      QSTART=0.
      DO 620 I=1,NMDSS
         QSTART=QSTART+PCTNAIR(I)*(1.-UHK(I)*EBO(IESTART)/TI)**IQPA(I)
  620 CONTINUE
      IF(QSTART.GT..99999)GO TO 700
      QSLOG=ALOG(QSTART)
      QNLOG=QSLOG
      IF(IESTART.GE.NEBOS)GO TO 700
      IELAST=IESTART
C
C
C**** LOOP THROUGH THE REST OF THE EBO ARRAY, COMPUTING AVAILABILITIES
C****   AND THE MARGINAL IMPROVEMENT/COST, AND CONVEXIFYING.
      DO 680 IE=IESTART+1,NEBOS
         IF(EBO(IE).GE.EBO(IELAST))GO TO 680
         QLLOG=QNLOG
C
C*    === COMPUTE AVAILABILITY.
         QNOW=0.
         DO 640 I=1,NMDSS
            QNOW=QNOW+PCTNAIR(I)*(1.-UHK(I)*EBO(IE)/TI)**IQPA(I)
  640    CONTINUE
         QNLOG=ALOG(QNOW)
C
C*    === COMPUTE MARGINAL IMPROVEMENT/COST AND ANNEX TO ARRAYS.
         NSVS=NSVS+1
         GLCOST(NSVS)=COST*(IE-IELAST)
         SV(NSVS)=(QNLOG-QLLOG)/GLCOST(NSVS)
         IGLQTY(NSVS)=IE-IELAST
         NDOUT(NSVS)=NDOUT(IE)
         IELAST=IE
C
C*    === CONVEXIFY.  IF ALREADY CONVEX, CONTINUE TO NEXT EBO.
  650    IF(SV(NSVS).LT.SV(NSVS-1))GO TO 660
            NSVOLD=NSVS
            NSVS=NSVS-1
            SUM=SV(NSVS)*IGLQTY(NSVS)+SV(NSVOLD)*IGLQTY(NSVOLD)
            IGLQTY(NSVS)=IGLQTY(NSVS)+IGLQTY(NSVOLD)
            SV(NSVS)=SUM/IGLQTY(NSVS)
            NDOUT(NSVS)=NDOUT(NSVOLD)
            GO TO 650
C
C*    === EXIT IF Q NEAR 1.
  660    IF(QNOW.GT..99999)GO TO 700
C
  680 CONTINUE
C
C
C
C***********************************************************************
C**** NOW WRITE COMPONENT TO TAPE.  FC 1 CONTAINS COMPLETE DATA
C****   FOR GENERATING SHOPPING LISTS.  FC 2 CONTAINS (AFTER SORTING)
C****   THE AVAILABILITY/COST CURVE.
  700 NWRITES=NWRITES+1
      IF(QNOW.LT.0.99)DEBUG=.T.
      WRITE(1)WUC,PN,SMR,COST,NEGAS,LUMPD,FF,IQPA,BNRTS,CONPCT,PLT
     & ,BRT,DRT,OST,NSVS,QSLOG,EBOO,NDOUTO,IESTART
      IF(DEBUG)WRITE(6,750)WUC,PN,SMR,COST,NEGAS,LUMPD,FF,IQPA,BNRTS
     & ,CONPCT,PLT,BRT,DRT,OST,NSVS,QSLOG,EBOO,NDOUTO,IESTART
```

```
 750 FORMAT("O WUC= ",A8,"   PN= ",A14,"   SMR= ",A7,"   COST= ",F9.0,
    & ,"   NEGAS,LUMPD= ",2I5,"   FF= ",F6.3,"   IQPA= ",2(I3),/
    & ,"   BNRTS= ",F4.2,"   CONPCT= ",F4.2,"   PLT= ",F4.0,"   BRT= ",
    & ,F4.0,"   DRT= ",F4.0,"   OST= ",F4.0,"   NSVS= ",I6,/
    & ,"   QSLOG= ",E11.4,"   EBOO= ",F8.3,"   NDOUTO,IESTART=",2I5)
     WRITE(2)1000.+COST*(LUMPD+IESTART),QSLOG
     IF(NSVS.EQ.0)GO TO 100
     DO 800 I=1,NSVS
        WRITE(1)SV(I),IGLQTY(I),NDOUT(I)
        WRITE(2)SV(I),IGLQTY(I)*COST
 800 CONTINUE
     IF(.NOT.DEBUG)GO TO 100
        WRITE(6,760)
 760    FORMAT("O EBO,SV,IGLQTY, & NDOUT ARRAYS")
        WRITE(6,770)(EBO(I),I=1,NEBOS)
 770    FORMAT(9F8.3)
        WRITE(6,780)(SV(I),I=1,NSVS)
 780    FORMAT(7E10.3)
        WRITE(6,790)(IGLQTY(I),I=1,NSVS)
 790    FORMAT(14I5)
        WRITE(6,790)(NDOUT(I),I=1,NSVS)
     GO TO 100
C
C
C
C
C
C
C*****************************************************************
C*****************************************************************
C**** END LOGIC.  PRINT FINAL STATISTICS.
 999 WRITE(6,1)" NREADS,NWRITES,TSUNKL,TSUNKN,TSUNKIE=",
    & NREADS,NWRITES,TSUNKL,TSUNKN,TSUNKIE
     STOP
     END
```

```
C ** ** LA61A/SLAY/SOURCE/VM/LUMPDGVM  11/19/80  BY FMS
C
C THIS PROGRAM USES THE FOLLOWING SUBROUTINES UNDER LA61A/LMILIB
C   DFACTLN
C   DLNGAMMA
C-----------------------------------------
C
       SUBROUTINE LUMPDGVM(DPIPE,ALPHA
      & ,LUMPD,DEBO,DREBO,DTERM,DEPOTM2,DEPOTCF,DQM1OVRQ,DPIPOVRQ)
C**** DPIPE IS THE EXPECTED NUMBER IN DEPOT RESUPPLY.
C****   IF DPIPE AND ALPHA ARE LARGE ENOUGH, SOME SPARES CAN BE
C****   ALLOCATED THE DEPOT WITH THE CERTAIN KNOWLEDGE THAT THEY
C****   WILL NEVER BE IDLE.  I.E. SOME OF THE SPARES GIVE AN EBO
C****   REDUCTION OF 1.  THE NUMBER OF SUCH SPARES IS LUMPD AND THE
C****   MODEL WILL ALLOCATE LUMPD SPARES TO THE DEPOT AS A SACROSANCT
C****   MINIMUM STOCK.  IF DPIPE OR LUMPD IS SMALL LUMPD=0.
C****   DEBO IS THE DEPOT EXPECTED BACKORDERS (=DPIPE-LUMPD)
C****   DREBO IS THE EBO REDUCTION FOR THE (LUMPD+1)'TH SPARE.
C****   DTERM IS THE PROB. THAT EXACTLY LUMPD SPARES ARE IN DEPOT
C****   RESUPPLY.  DEPOTM2 IS THE EXPECTED VALUE OF THE SQUARE OF THE
C****   NUMBER OF DEPOT BACKORDERS.
       DQ=1.+DPIPE/ALPHA
       DQM1OVRQ=(DQ-1.)/DQ
       DPIPOVRQ=DPIPE/DQ
       LUMPD=DPIPE-3.*SQRT(DPIPE*DQ)
       IF(LUMPD.LE.0)LUMPD=0
C**** IF LUMPD>0 GO TO BIG LUMP PROCESSING
       IF(LUMPD.NE.0)GO TO 200
C
C   ==== SIMPLE CASE
           DEBO=DPIPE
           TRMLOG=-DPIPE
           IF(DQ.GE.1.00001)TRMLOG=DPIPE*(ALOG(DQ)/(1.-DQ))
           DTERM=EXP(TRMLOG)
           DREBO=1.-DTERM
           DEPOTM2=DEBO*DEBO+DPIPE*DQ
C*     === DEBO > 100 NOT ALLOWED
   100     IF(DEBO.LE.100.)GO TO 999
           DEBO=DEBO-DREBO
           DEPOTM2=DEPOTM2-DEBO-DEBO-DREBO
           DTERM=DTERM*(DPIPOVRQ+DQM1OVRQ*LUMPD)/(LUMPD+1)
           DREBO=DREBO-DTERM
           LUMPD=LUMPD+1
           GO TO 100
C
C   ==== BIG LUMP PROCESSING.  CAN GET STICKY.
C   ====    IF DQ IS CLOSE TO 1. TREAT AS A POISSON
   200     IF(DQ.LE.1.00001)GO TO 500
C
C       ---- ELSE DO FULL NEGATIVE BINOMIAL.
             ISTART=LUMPD+LUMPD-DPIPE
             IF(ISTART.LE.0)ISTART=0
             PPOVRQM1=ALPHA
             TRMLOG=(-PPOVRQM1)*ALOG(DQ)
C       ---- GETTING STICKIER.  IF ISTART>0 COMPUTE P(ISTART)
C       ----    DLNGAMMA BASED PROCESSING
             IF(ISTART.EQ.0)GO TO 300
C
C         ---- COMPUTE LOG OF P OF ISTART
               TRMLOG=TRMLOG+ISTART*ALOG(DQM1OVRQ)+
      &        SNGL(DLNGAMMA(PPOVRQM1+ISTART)-DFACTLN(ISTART)
      &        -DLNGAMMA(PPOVRQM1))
C
C       ---- ITERATE FROM ISTART TO LUMPD.
```

```
  300        DEBO=DPIPE-ISTART
             DTERM=EXP(TRMLOG)
             DREBO=1.-DTERM
             DEPOTM2=DPIPE*DQ+DEBO*DEBO
             DO 400 I=ISTART+1,LUMPD
C
                DEBO=DEBO-DREBO
                DEPOTM2=DEPOTM2-DEBO-DEBO-DREBO
                DTERM=DTERM*(DQM1OVRQ*(I-1)+DPIPOVRQ)/I
                DREBO=DREBO-DTERM
C
  400        CONTINUE
             GO TO 999
C
C        ---- DQ CLOSE TO 1.  TREAT AS POISSON.
  500        ISTART=LUMPD+LUMPD-DPIPE
             IF(ISTART.LE.0)ISTART=0
             TRMLOG=-DPIPE
             IF(ISTART.NE.0)TRMLOG=TRMLOG+ISTART*ALOG(DPIPE)-
     &       SNGL(DFACTLN(ISTART))
             DEBO=DPIPE-ISTART
             DTERM=EXP(TRMLOG)
             DREBO=1.-DTERM
             DEPOTM2=DPIPE+DEBO*DEBO
             DQM1OVRQ=0.
             DPIPOVRQ=DPIPE
             DO 600 I=ISTART+1,LUMPD
C
                DEBO=DEBO-DREBO
                DEPOTM2=DEPOTM2-DEBO-DEBO-DREBO
                DTERM=DTERM*DPIPE/I
                DREBO=DREBO-DTERM
C
  600        CONTINUE
C
  999 IF(DPIPE.GT.0.)DEPOTCF=1./(1.+ALPHA/DPIPE)
      RETURN
      END
```

```
C ** ** LA61A/SLAY/SOURCE/VM/BINITGVM  11/19/80  BY FMS
C
      SUBROUTINE BINITGVM(DEBO,DEPOTM2,DEPOTCF,BSHARE,BOPIPE,ALPHA,
     & BPIPE,Q,QM1OVERQ,PIPEOVRQ,EBO,REBO,TERM)
C**** THIS SUBROUTINE INITIALIZES THE NEGATIVE BINOMIAL PDF AT A
C****   BASE.  BPIPE IS THE EXPECTED NUMBER IN RESUPPLY AT A BASE.
C****   Q IS THE VARIANCE TO MEAN RATIO OF THE # IN RESUPPLY AT A BASE.
C****   REBO IS THE EBO REDUCTION FOR THE FIRST SPARE AT A BASE.
C****   TERM IS THE PROBABILITY THE EXACTLY LUMP ARE IN RESUPPLY FOR
C****   A PARTICULAR BASE.  EBO IS THE TOTAL WORLDWIDE EBO WITH
C****   LUMP SPARES AT EACH BASE (AND ND AT THE DEPOT).
C
      EBO=BOPIPE+DEBO
      DDELMEAN=DEBO*BSHARE
      B1BOPIPE=BSHARE*BOPIPE
      B1BOVAR=B1BOPIPE*(1.+B1BOPIPE/ALPHA)
      BPIPE=B1BOPIPE+DDELMEAN
      BVAR=B1BOPIPE
      DEPOTVAR=DEPOTM2-DEBO*DEBO
      IF(DEPOTVAR.LE.0.)GO TO 100
      DVPP=DEPOTVAR*BSHARE*BSHARE
      DDELVAR=DVPP+DDELMEAN*(1.-BSHARE)
      DDELCF=DVPP*DEPOTCF/DDELVAR
      B1BOCF=1./(1.+ALPHA/B1BOPIPE)
      BVAR=B1BOVAR+DDELVAR+2.*SQRT(B1BOVAR*DDELVAR*B1BOCF*DDELCF)
  100 Q=BVAR/BPIPE
C**** IF Q SMALL TREAT AS POISSON.
      IF(Q.LE.1.00001)GO TO 200
C
C    ==== ELSE INITIALIZE FOR NEGATIVE BINOMIAL
         PIPEOVRQ=BPIPE/Q
         QM1OVERQ=(Q-1.)/Q
         TERM=Q**(BPIPE/(1.-Q))
         REBO=1.-TERM
         GO TO 999
C
C    ==== TREAT AS POISSON.
  200    PIPEOVRQ=BPIPE
         QM1OVERQ=0.
         TERM=EXP(-BPIPE)
         REBO=1.-TERM
         Q=1.
C
C**** FINISH
  999 RETURN
      END
```

```
C ** ** LA61A/LMILIB/DLNGAMMA  11/18/80  BY FMS
C
      DOUBLE PRECISION FUNCTION DLNGAMMA(X)
C***
C*****    THIS FUNCTION COMPUTES THE NATURAL LOG OF GAMMA OF X
C***
       IMPLICIT DOUBLE PRECISION(D)
C*** *DSIGMA IS A CONSTANT =LN(SQRT(2*PI))
      DATA DSIGMA/.91893 85332 04672 74178 DO/
      IF(X.LE.9.9)PRINT," <*> DLNGAMMA PASSED SMALL X=",X
C***
C***          *COMPUTE VARIOUS PARTS NEEDED FOR THE APPROXIMATION
              DPN=DBLE(X-1.)
              DLNGAMMA = (DPN + .5DO)*DLOG(DPN) - DPN + DSIGMA
&                      + 1.0DO/(12.0DO*DPN)
&                      - 1.0DO/(360.0DO*DPN*DPN*DPN)
C***
       RETURN
       END
```

```
C ** ** LA61A/LMILIB/DFACTLN  BY MJK
C
        DOUBLE PRECISION FUNCTION DFACTLN(N)
C***
C*****     THIS FUNCTION COMPUTES THE LOGARITHM (BASE E) OF
C***** 'N' FACTORIAL.
C***
        PARAMETER MAXTBLE=30
        IMPLICIT DOUBLE PRECISION(D)
        DIMENSION DTABLE(MAXTBLE)
        EQUIVALENCE (DTABLE(0),DZERO)
C***   *DSIGMA IS A CONSTANT = LN(SQRT(2*PI))
        DATA DSIGMA/.91893 85332 04672 74178D0 /
C***   *DZERO IS THE LOGARITHM (BASE E) OF 0!
        DATA DZERO/0.0D0/
C***   *DTABLE(I) IS THE LOGARITHM (BASE E) OF I!
        DATA DTABLE/
     &                     0.0D0,
     & .69314718055994531D0,
     & .17917594692280550D1,
     & .31780538303479456D1,
     & .47874917427820459D1,
     & .65792512120101009D1,
     & .85251613610654143D1,
     & .10604602902745250D2,
     & .12801827480081469D2,
     & .15104412573075515D2,
     & .17502307845873885D2,
     & .19987214495661886D2,
     & .22552163853123422D2,
     & .25191221182738681D2,
     & .27899271383840891D2,
     & .30671860106080672D2,
     & .33505073450136888D2,
     & .36395445208033053D2,
     & .39339884187199494D2,
     & .42335616460753485D2,
     & .45380138898476908D2,
     & .48471181351835223D2,
     & .51606675567764373D2,
     & .54784729398112319D2,
     & .58003605222979157D2,
     & .61261701761002002D2,
     & .64557538627006331D2,
     & .67889743137181534D2,
     & .71257038967168009D2,
     & .74658236348830164D2
     &/
C***
C***        *IF(N IS WITHIN THE TABLE LIMITS)
             IF((N.LT.0) .OR. (N.GT.MAXTBLE)) GO TO 100
C***
C***           *RETURN TABLE VALUE
                DFACTLN = DTABLE(N)
C***
C***        *ELSE (USE STIRLING'S APPROXIMATION - SEE KNUTH VOL 1,P 111)
             GO TO 200
  100        CONTINUE
C***
C***           *COMPUTE VARIOUS PARTS NEEDED FOR THE APPROXIMATION
                DPN = DBLE(FLOAT(N))
                DFACTLN = (DPN + .5D0)*DLOG(DPN) - DPN + DSIGMA
&                         + 1.0D0/(12.0D0*DPN)
&                         - 1.0D0/(360.0D0*DPN*DPN*DPN)
```

```
C***
C***         *END IF (TABLE LIMITS TEST)
  200         CONTINUE
C***
        RETURN
        END
```

APPENDIX B

THE F-16 PROGRAM

We chose the F-16 aircraft as a case study for examining alternative spares acquisition strategies for a number of reasons. First, the program is recent and data were available in enough detail to support the study. Second, the program had been in operation long enough to have meaningful maintenance data from which we could infer recoverable spares demand rates. Third, the F-16 program has had the reputation of being a well-run program, producing aircraft without substantial time delays and costly design changes. As background we will discuss the history of the F-16 program, the data for F-16 recoverable components excluding the engine and common items.

The late 1960s brought increasingly complex and costly weapon systems. Because of escalating costs during a time of overall defense spending cuts (in constant dollars), the idea of a lightweight fighter (LWF) became increasingly popular. With the lower cost of a LWF, more aircraft could be purchased for a specified investment, and the greater number of aircraft would enhance the presence, battle persistence, resilience, and sortie rate. The LWF advantages were advocated to Congress as early as 1968, but it was not until April 1972 that the LWF program got underway. At that time the Air Force selected General Dynamics and Northrup to design and test-fly two prototypes each.

The LWF program included several factors intended to provide a low-cost, timely fighter aircraft. These factors included fixed-price contracts for design, production and test flights of prototypes, a fixed-price, full-scale production contract, and concurrency of tasks. Part of task concurrency

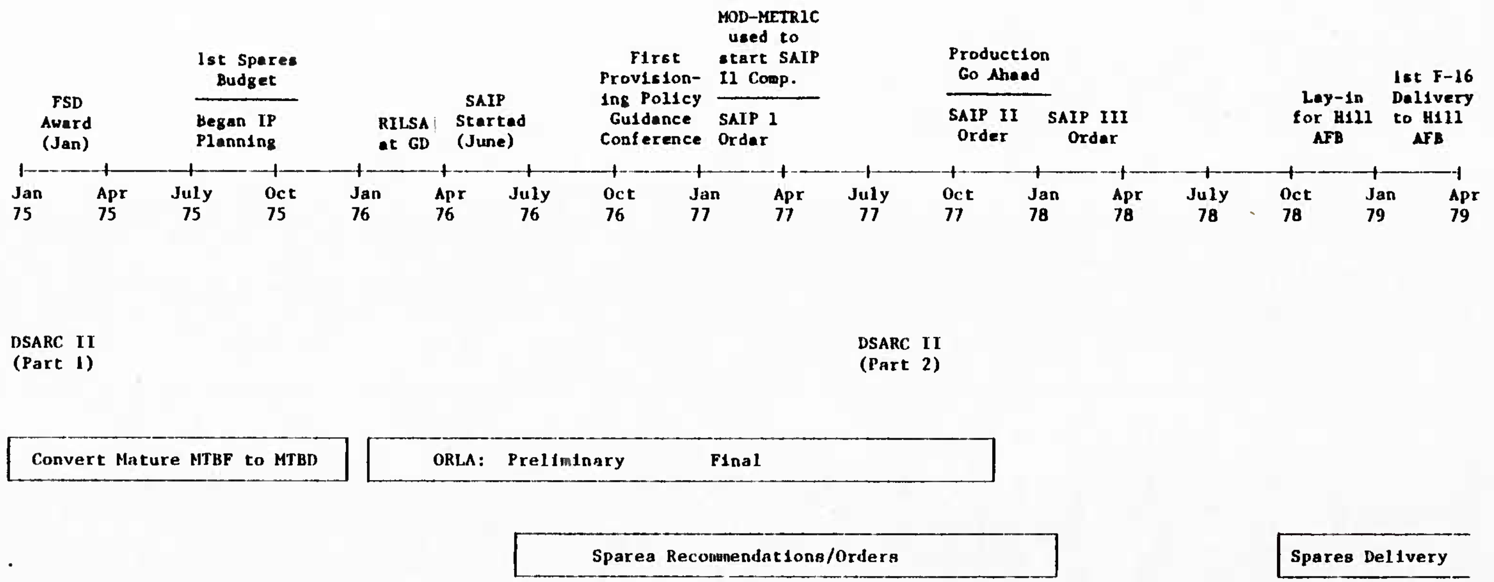
involved an early decision on initial provisioning (IP) purchases. Design goals were set in the areas of acceleration, cruise speed, sustained turning radius, and radius of action. However, the contract did not require the aircraft to meet detailed specifications and placed an unusually large portion of the design and scheduling responsibilities on the contractor.

The General Dynamics prototypes were rolled out in December 1973 and Northrup's in April 1974. The competitive prototype approach was credited for a program with a minimum of paperwork, responsive decision making, and a fast-paced developmental effort (22 months from contract to first flight, compared with 37 months for the C-5A, 29 months for the F-111, and 30 months for the F-15).

Both contractors' aircraft met or exceeded expected performance levels. In September 1974, the Department of Defense announced that it would buy 650 LWF for the Air Force. The selection of the General Dynamics F-16 was announced in January 1975. Eight aircraft were tested during the pre-production full scale development (FSD) period from July 1975 to June 1978. In October 1977 the production contract was awarded. Figure C-1 shows the major milestones for the F-16 and its initial provisioning.

In the 1970s, the Air Force, like the Navy, increasingly emphasized reliability and maintainability because of the increasing cost of logistics support (due to manpower and equipment/component cost escalations). The F-16 program response was design simplicity. Of 432 major, recoverable components on the prototype aircraft, 254 were identical to those used in other aircraft, 78 were only slightly modified, and the remaining 100 components (only 23 percent) were new. The use of existing components, among other things, enhanced hardware reliability. In addition, interchangeable components were designed to minimize tooling as well as to reduce initial manufacturing and spares

FIGURE B-1. F-16 MILESTONES



costs. Eighty percent of the main landing gear parts are interchangeable on the F-16 and only 52 different types of fasteners (all standard) are used (compared to 250 types, for example, on the F-111).

The F-16 FSD contract included a formal reliability plan derived from MIL-STD-785A. A similar plan covered maintainability efforts. Reliability requirements were quantified for the F-16 and for its subsystems and equipment. The requirements are expressed in terms of mean flight time between failures (MFTBF). MFTBF is defined as total flight time divided by the total number of failures experienced in flight and on the ground. This is an expression of reliability performance from a maintenance viewpoint. Reliability data are the basis for the analysis of availability in this report.

APPENDIX C

AIRCRAFT MAINTENANCE ACTION-TAKEN CODES*

Code	Description
A	Bench checked and repaired Bench check and repair of any one item is accomplished at the same time. (Also see Code F.)
B	Bench checked-serviceable (No repair required)-item is bench checked and no repair is required.
C	Bench checked-repair deferred Bench check is accomplished and repair action is deferred. (See Code F).
D	Bench checked-transferred to another base or unit Item is bench checked at a forward operating base, dispersed operating base or enroute base and is found unserviceable and transferred to a main operating base or home base for repair. This code will not be used for items returned to a depot for overhaul. This code will also be used when PME or other equipment is sent to another base or unit for bench check, calibration, or repair and is to be returned, and for items forwarded to contractors on base level contracts.
1	Bench checked-NRTS (Not Repairable This Station-Repair not authorized) Shop is not authorized to accomplish the repair. This code shall only be used when the repair required to return an item to serviceable status is specifically prohibited by current technical directives. This code shall not be used due to lack of authority for equipment, tools, facilities, skills, parts or technical data.
2	Bench checked-NRTS-lack of equipment, tools, or facilities Repair is authorized but cannot be accomplished due to lack of authorized equipment, tools, or facilities.
3	Bench checked-NRTS-lack of technical skills Repair cannot be accomplished due to lack of technically qualified people.

* Reference [13]

Code	Description
4	Bench checked-NRTS-lack of parts Parts are not available to accomplish repair.
5	Bench checked-NRTS-shop backlog Repair cannot be accomplished due to excessive shop backlog.
6	Bench checked-NRTS-lack of technical data Repair cannot be accomplished due to lack of maintenance manuals, drawings etc., which describe detailed repair procedures and requirements.
7	Bench checked-NRTS-lack of equipment, tools, facilities, skills, parts, or technical data Repair authorized, but cannot be accomplished due to lack of authorization to obtain or possess required equipment, tools, facilities, skills, parts, or technical data.
8	Bench checked-return to depot Returned to depot by direction of system manager (SM) or item manager (IM). Use only when items that are authorized for base level repair are directed to be returned to depot facilities by specific written or verbal communications from the IM or SM: or when items are to be returned to depot facilities for modification in accordance with a time compliance technical order (TCTO) or as UMR exhibits.
9	Bench-checked-condemned Item cannot be repaired and is to be processed for condemnation, reclamation or salvage. This code will also be used when a (condemned) condition is discovered during field maintenance disassembly or repair.
E	Initial installation For installation actions that are not related to a previous removal action such as installation of additional equipment or installation of an item to remedy a ship-short condition. This code will be used only for equipment managed under the advanced configuration management system. Reference T.O.'s 00-20-2-2, 00-20-2-5 and 00-20-2-7. Must be used with How Mal Code 799.

Code	Description
F	Repair
	Not to be used to code 'on-equipment' work if another code will apply. When it is used in a shop environment, this code will denote repair as a separate unit of work after a bench check. Shop repair includes the total repair manhours and includes cleaning, disassembly, inspection, adjustment, reassembly and lubrication of minor components incident to the repair when these services are performed by the same work center. For precision measurement equipment, this code will be used only when calibration of the repaired item is required (see code G).
G	Repairs and/or replacement of minor parts, hardware and softgoods
	(Seals, gaskets, electrical connectors, fittings, tubing, hose, wiring, fasteners, vibration isolators, brackets, etc.) Work unit codes do not cover most nonrepairable items, therefore, when items such as those identified above are required or replaced, this action-taken code will be used. When this action-taken code is used, the work unit code will identify the assembly being serviced or most directly related to parts being repaired or replaced. For example, if an electrical connector was repaired and was attached to a radio transmitter, the work unit code for the transmitter would be used with this action-taken code. For precision measurement equipment this code will be used for repairs that do not require calibration of the repaired item (see code F).
H	Equipment checked - no repair required (for 'on-equipment' work only)
	All discrepancies which are checked and found to require no further maintenance action. This code will be used only if it is definitely determined that a reported deficiency does not exist or cannot be duplicated. Must be used with How Mal Code 799, 812 or 948.
J	Calibrated - no adjustment required
	Use this code when an item is calibrated and found serviceable without need for adjustment, or is found to be in tolerance but is adjusted merely to peak or maximize the reading. If the item requires adjustment to actually meet calibration standards or to bring in tolerance, use code K.
K	Calibrated - adjustment required
	Item must be adjusted to bring it in tolerance or meet calibration standards. If the item was repaired or needs repair in addition to calibration and adjustment, use code F.

Code	Description
L	Adjust Includes adjustments necessary for safety and proper functioning of equipment such as adjust, bleed, balance, rig, fit, reroute, seat/reseat, position/reposition, or actuating reset button, switch or circuit breaker. For use when a discrepancy or condition is corrected by these types of actions. If the identified component or assembly also requires replacement of bits and pieces as well as adjustment, enter the appropriate repair action-taken code instead of L.
M	Disassemble Disassembly action when the complete maintenance job is broken into parts and reported as such. Do not use for on-equipment work.
N	Assemble Assembly action when the complete maintenance job is broken into parts and reported as such. Do not use for on-equipment work.
P	Removed Item is removed and only the removal is to be accounted for. In this instance delayed or additional actions will be accounted for separately. (Also see codes Q, R, S, T, and U.) Do not use for off-equipment work.
Q	Installed Item is installed and only the installation action is to be accounted for. (Also see codes E, P, R, S, T, and U.) Do not use for off-equipment work.
R	Remove and replace Item is removed and another like item is installed. (Also see codes T and U.) Do not use for off-equipment work.
S	Remove and reinstall Item is removed and the same item reinstalled. (Also see codes T and U.) Do not use for off-equipment work. Must be used with How Mal Code 800, 804, or 805.
T	Removed for cannibalization A component is cannibalized. The work unit code will identify the component being cannibalized. Do not use this code for off-equipment work. Must be used with How Mal Code 799.

Code	Description
U	Replaced after cannibalization
	This code will be entered when a component is replaced after cannibalization. Do not use this code for off-equipment work. Must be used with How Mal Code 799.
V	Clean
	Cleaning is accomplished to correct discrepancy and/or when cleaning is not accounted for as part of a repair action such as code F. Includes washing, acid bath, buffing, sand blasting, degreasing, decontamination, etc. Cleaning and washing of complete items such as ground equipment, vehicles, missiles or aircraft should be recorded by utilizing support general codes.
X	Test-inspection-service
	Item is tested or inspected or serviced (other than bench check) and no repair is required. This code does not include servicing or inspection chargeable to support general work unit codes.
Y	Troubleshoot
	Time expended in locating a discrepancy is great enough to warrant separating the troubleshoot time from the repair time. Use of this code necessitates completion of two separate line entries, or two separate forms, one for the troubleshoot phase and one for the repair phase. When recording the troubleshoot time separate from the repair time, the total time taken to isolate the primary cause of the discrepancy should be recorded utilizing the work unit code of the defective subsystem or system. Do not use for off-equipment work.
Z	Corrosion repair
	Includes cleaning, treating, priming and painting of corroded items. This code should always be used when actually treating corroded items, either on equipment or in the shop. The work unit code should identify the item that is corroded. Use support general code for painting or corrosion preventive treatment prior to an item becoming corroded.

APPENDIX D

COMPONENT MAINTENANCE FACTORS

Each of the F-16 recoverable components used for the analysis of this report is identified in the following listing by work unit code (WUC). The nomenclature associated with each WUC can be found in [4]. On the listing there are several maintenance factors (MF) associated with each component:

- the estimated MF from the ORLA/DORR process described in Chapter 2 (ORLA EST),
- the MF computed using the failures reported during the first six months of operation (January 1979 to May 1979)(6M MEAS),
- the MF computed using the failures reported during the first six months of operation to modify the ORLA estimates as prescribed by DoDI 4140.42 (6M 7525),
- the MF computed using the failures reported during the first six months of operation to modify the ORLA estimates in the Bayesian sense described in Chapter 4 (6M BAYES),
- the MF computed using the failures reported during the first six months of operation to modify the ORLA estimates using the "BAYES-LIN" method described in Chapter 4 (6M B-L),
- the MF computed using the failures reported during the last 24 months (July 1979 to June 1981) of operation to modify the ORLA estimates using the Baysian method described in Chapter 3 (24M 'ACT') and,
- the MF computed using the failures reported from January 1979 to June 1981 (30M MEAS).

This listing shows, on a component-by-component basis, the differences between the ORLA estimates of MF, revised estimates, and the MF implied by actual reported failures to date.

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
11ABA	0.2500	0.	0.2500	0.0733	0.0496	0.0056	0.0037
11ABB	0.1000	0.	0.1000	0.0342	0.0231	0.0019	0.0009
11ABC	0.1000	0.	0.1000	0.0342	0.0231	0.0009	0.
11ACA	0.0080	0.	0.0080	0.0074	0.0050	0.0015	0.
11ACB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ACC	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ADA	0.0080	0.	0.0080	0.0074	0.0050	0.0030	0.0018
11ADB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ADC	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11AEA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CBA	0.0050	0.	0.0050	0.0049	0.0033	0.0028	0.
11CBC	0.0040	0.	0.0040	0.0039	0.0026	0.0013	0.
11CBD	0.0040	0.	0.0040	0.0039	0.0027	0.0064	0.0080
11CBE	0.0500	0.	0.0500	0.0388	0.0262	0.0163	0.0118
11CCA	0.0050	0.	0.0050	0.0049	0.0033	0.0028	0.
11CCB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CCC	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CDA	0.0040	0.	0.0040	0.0039	0.0026	0.0038	0.0037
11CDC	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CDD	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CDF	0.0020	0.	0.0020	0.0020	0.0013	0.0116	0.0202
11CDG	0.0010	0.	0.0010	0.0010	0.0007	0.0005	0.
11CDH	0.0010	0.	0.0010	0.0010	0.0007	0.0005	0.
11CDK	0.0010	0.	0.0010	0.0010	0.0007	0.0007	0.
11CEA	0.0040	0.	0.0040	0.0039	0.0027	0.0016	0.
11CEB	0.0040	0.	0.0040	0.0039	0.0027	0.0016	0.
11CED	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CEE	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11CEF	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CEG	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CEH	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CEJ	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CEL	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11CEN	0.0040	0.	0.0040	0.0039	0.0027	0.0016	0.
11CET	0.0050	0.	0.0050	0.0049	0.0033	0.0028	0.
11EBA	0.0050	0.	0.0050	0.0042	0.0028	0.0004	0.
11EBB	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11EBD	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EBE	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EBH	0.0050	0.	0.0050	0.0042	0.0028	0.0004	0.
11EBK	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EBL	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EBM	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ECA	0.0050	0.	0.0050	0.0042	0.0028	0.0004	0.
11ECB	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11ECC	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ECD	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ECE	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ECF	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ECH	0.0050	0.	0.0050	0.0042	0.0028	0.0009	0.0005

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
11ECJ	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11ECK	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11ECL	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11ECM	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDA	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11EDC	0.0050	0.	0.0050	0.0048	0.0032	0.0041	0.0037
11EDD	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11EDH	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDJ	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDM	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDN	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDP	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDR	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDS	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EDT	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEA	0.0050	0.	0.0050	0.0049	0.0033	0.0018	0.
11EEB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEC	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEE	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEF	0.0040	0.	0.0040	0.0039	0.0026	0.0013	0.
11EEG	0.0040	0.	0.0040	0.0039	0.0026	0.0025	0.0018
11EEH	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEJ	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11EEK	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEL	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEM	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11EEN	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEP	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEQ	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EER	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EEV	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EEW	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EEY	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EEZ	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EFA	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EFB	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EFC	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EFD	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EFE	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EFF	0.0050	0.	0.0050	0.0034	0.0023	0.0002	0.
11EFG	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EFH	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11EFK	0.0050	0.	0.0050	0.0049	0.0033	0.0028	0.
11EFL	0.0500	0.	0.0500	0.0388	0.0262	0.0054	0.
11EFM	0.0500	0.	0.0500	0.0388	0.0262	0.0109	0.0059
11EFN	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11EFP	0.0050	0.	0.0050	0.0049	0.0033	0.0028	0.
11GBA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GBB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GBF	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
11GBG	0.0500	0.	0.0500	0.0337	0.0228	0.0018	0.
11GBH	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GCA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GCG	0.0500	0.	0.0500	0.0337	0.0228	0.0018	0.
11GCH	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GCK	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GDA	0.0500	0.2076	0.0894	0.1012	0.0684	0.0090	0.0110
11GDB	0.0500	0.	0.0500	0.0337	0.0228	0.0054	0.0037
11GDC	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GDE	0.0500	0.	0.0500	0.0337	0.0228	0.0144	0.0128
11GDF	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11GDG	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GDR	0.0500	0.	0.0500	0.0337	0.0228	0.0144	0.0128
11GDS	0.0500	0.	0.0500	0.0337	0.0228	0.0108	0.0092
11GEA	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11GEB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEC	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GED	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEE	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11GEF	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEJ	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11GEK	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEL	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEM	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEN	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEP	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GEQ	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGE	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGF	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGG	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGJ	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGK	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGL	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGM	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGN	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11GGP	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11JBA	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11JBB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11JBH	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11JBJ	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11JBK	0.5000	0.	0.5000	0.0860	0.0581	0.0019	0.
11JBL	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11JBM	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11JCA	0.0280	0.	0.0280	0.0221	0.0149	0.0018	0.
11JDB	0.0010	0.	0.0010	0.0010	0.0007	0.0013	0.0018
11LBA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11LBD	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11LBE	0.0060	0.	0.0060	0.0057	0.0038	0.0014	0.
11LDA	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
11LDB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11LDM	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11LDN	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11LEA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11LEB	0.0020	0.	0.0020	0.0019	0.0013	0.0006	0.
11LEF	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11LEH	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11LEK	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11LFA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11MBA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11MBE	0.0060	0.	0.0060	0.0057	0.0038	0.0014	0.
11MBF	0.0060	0.	0.0060	0.0057	0.0038	0.0014	0.
11MCG	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11MDA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11MDB	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11MDM	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
11MDN	0.0020	0.	0.0020	0.0020	0.0013	0.0019	0.0018
11MEA	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
11MEB	0.0020	0.	0.0020	0.0019	0.0013	0.0006	0.
11MEF	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11MEH	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
11MEK	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
12AAA	0.0550	0.	0.0550	0.0360	0.0243	0.0018	0.
12AAA-B	0.0040	0.	0.0040	0.0039	0.0026	0.0024	0.
12AAB	0.6200	0.	0.6200	0.0889	0.0601	0.0019	0.
12AAB-B	0.0670	0.	0.0670	0.0484	0.0327	0.0056	0.
12AAC	1.6000	0.	1.6000	0.0975	0.0659	0.0019	0.
12AAC-B	0.0670	0.	0.0670	0.0484	0.0327	0.0056	0.
12AAD	0.6200	0.	0.6200	0.0889	0.0601	0.0037	0.0018
12AAE	0.6200	0.	0.6200	0.0889	0.0601	0.0019	0.
12AAF	0.1000	0.	0.1000	0.0394	0.0266	0.0028	0.0014
12AAG	0.1000	0.	0.1000	0.0394	0.0266	0.0014	0.
12ABA	0.0150	0.	0.0150	0.0131	0.0089	0.0017	0.
12ACA	0.0360	0.	0.0360	0.0267	0.0181	0.0018	0.
12ACA-B	0.0018	0.	0.0018	0.0018	0.0012	0.0014	0.
12ACB	0.2000	0.	0.2000	0.0683	0.0462	0.0019	0.
12ACB-B	0.1450	0.	0.1450	0.0790	0.0534	0.0058	0.
12ADA	0.0360	0.	0.0360	0.0267	0.0181	0.0018	0.
12ADA-B	0.0018	0.	0.0018	0.0018	0.0012	0.0014	0.
12ADB	0.2000	0.	0.2000	0.0683	0.0462	0.0019	0.
12ADB-B	0.0218	0.	0.0218	0.0194	0.0131	0.0048	0.
12AEA	0.0360	0.	0.0360	0.0316	0.0214	0.0025	0.
12AEA-B	0.0020	0.	0.0020	0.0020	0.0013	0.0015	0.
12AEB-B	0.0410	0.	0.0410	0.0332	0.0224	0.0053	0.
12AED	0.1950	0.	0.1950	0.1110	0.0750	0.0159	0.0133
12AED-B1	0.0300	0.	0.0300	0.0256	0.0173	0.0051	0.
12AED-B2	0.0180	0.	0.0180	0.0163	0.0110	0.0046	0.
12AEH	0.0080	0.	0.0080	0.0071	0.0048	0.0012	0.
12AFA	0.0360	0.	0.0360	0.0267	0.0181	0.0018	0.
12AFA-B	0.0018	0.	0.0018	0.0018	0.0012	0.0014	0.

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
12AFC	0.0002	0.	0.0002	0.0002	0.0001	0.0002	0.
12AGA	0.5500	0.	0.5500	0.0873	0.0590	0.0019	0.
12AGA-B	0.0620	0.	0.0620	0.0457	0.0309	0.0056	0.
12AGB	0.5500	0.	0.5500	0.0873	0.0590	0.0019	0.
12AGB-B	0.0602	0.	0.0602	0.0447	0.0302	0.0055	0.
12CA0-A	0.1300	0.	0.1300	0.0864	0.0584	0.0105	0.0080
12CA0-B	0.1300	0.	0.1300	0.0744	0.0503	0.0058	0.
12CAC-A	0.1280	0.	0.1280	0.0855	0.0578	0.0026	0.
12CAC-B	0.1280	0.	0.1280	0.0737	0.0498	0.0058	0.
12CAG	0.0050	0.	0.0050	0.0049	0.0033	0.0028	0.
12CBA	0.0400	0.	0.0400	0.0289	0.0195	0.0018	0.
12CC0	0.7750	0.	0.7750	0.1934	0.1307	0.0134	0.0106
12CC0-B	0.7750	0.	0.7750	0.1419	0.0959	0.0060	0.
12CEA	0.0420	0.	0.0420	0.0361	0.0244	0.0025	0.
12ZA0	0.0300	0.	0.0300	0.0233	0.0157	0.0053	0.0037
12ZB0	0.0465	0.	0.0465	0.0321	0.0217	0.0072	0.0055
12ZC0	0.2022	0.	0.2022	0.0686	0.0463	0.0240	0.0220
13AAA	0.0900	0.	0.0900	0.0482	0.0326	0.0055	0.0037
13AAC	0.0150	0.1038	0.0372	0.0262	0.0177	0.0547	0.0605
13AAD	0.0150	0.	0.0150	0.0131	0.0089	0.0282	0.0293
13AAE	0.0160	0.	0.0160	0.0147	0.0099	0.0221	0.0235
13ABA	0.0050	0.	0.0050	0.0048	0.0032	0.0054	0.0055
13ABB	0.0200	0.	0.0200	0.0168	0.0113	0.0051	0.0037
13ABD	0.0010	0.	0.0010	0.0010	0.0007	0.0052	0.0128
13ABE	0.0050	0.	0.0050	0.0049	0.0033	0.0028	0.
13BAB	0.0768	0.0519	0.0706	0.0619	0.0419	0.0018	0.0018
13BAC-01	0.0060	0.	0.0060	0.0057	0.0038	0.0100	0.0110
13BAC-02	0.0060	0.	0.0060	0.0057	0.0038	0.0014	0.
13BAD	0.0030	0.	0.0030	0.0028	0.0019	0.0050	0.0055
13BAF-01	0.0640	0.	0.0640	0.0396	0.0268	0.0018	0.
13BAF-02	0.0650	0.	0.0650	0.0400	0.0270	0.0018	0.
13BAH	0.0150	0.	0.0150	0.0131	0.0089	0.0017	0.
13BAJ	0.0160	0.	0.0160	0.0139	0.0094	0.0017	0.
13BAK	0.0320	0.	0.0320	0.0198	0.0134	0.0009	0.
13BAL	0.0015	0.	0.0015	0.0015	0.0010	0.0006	0.
13BBA	0.1950	0.	0.1950	0.0410	0.0277	0.0009	0.
13BBD	0.0300	0.	0.0300	0.0190	0.0129	0.0009	0.
13BBE	0.1950	0.	0.1950	0.0294	0.0199	0.0006	0.
13CAA	0.0330	0.1038	0.0507	0.0501	0.0338	0.0141	0.0147
13CAG	0.0170	0.	0.0170	0.0146	0.0099	0.0017	0.
13CAK	0.0104	0.	0.0104	0.0095	0.0064	0.0032	0.0018
13CBA	0.0520	0.	0.0520	0.0346	0.0234	0.0378	0.0366
13CBB	0.0550	0.2076	0.0931	0.1079	0.0729	0.0577	0.0605
13CBC	0.0290	0.	0.0290	0.0158	0.0107	0.0049	0.0043
13CBF	0.0330	0.	0.0330	0.0250	0.0169	0.0018	0.
13EAA	0.0650	0.	0.0650	0.0400	0.0270	0.0725	0.0715
13EAB	0.0390	0.	0.0390	0.0223	0.0151	0.0036	0.0028
13EAC	0.0390	0.	0.0390	0.0284	0.0192	0.0267	0.0257
13EAD	0.1050	0.1038	0.1047	0.1044	0.0705	0.0385	0.0385
13EAF	0.1050	0.1038	0.1047	0.1044	0.0705	0.0403	0.0403

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
13EAG	0.2000	0.	0.2000	0.0412	0.0278	0.0158	0.0147
13EAH	0.2660	0.1557	0.2384	0.1737	0.1174	0.2017	0.2006
13FAA	0.0600	0.2076	0.0969	0.1141	0.0771	0.0036	0.0055
13FAB	0.0050	0.	0.0050	0.0048	0.0032	0.0068	0.0073
13FAC	0.1050	0.	0.1050	0.0522	0.0353	0.0532	0.0513
13FAH-01	0.0600	0.	0.0600	0.0380	0.0257	0.0036	0.0018
13FAH-02	0.0600	0.	0.0600	0.0380	0.0257	0.0018	0.
13GAA	0.0110	0.	0.0110	0.0100	0.0067	0.0064	0.0055
13GAB	0.0260	0.	0.0260	0.0208	0.0141	0.0139	0.0128
13GAE	0.0400	0.	0.0400	0.0289	0.0195	0.0160	0.0147
14AA0	2.0000	0.1038	1.5259	0.1973	0.1334	0.5553	0.5460
14AAA	0.0310	0.	0.0310	0.0141	0.0095	0.0055	0.0050
14AAB	0.0360	0.	0.0360	0.0151	0.0102	0.0023	0.0018
14AAC	0.0330	0.	0.0330	0.0145	0.0098	0.0032	0.0028
14AAD	0.0340	0.	0.0340	0.0147	0.0100	0.0037	0.0032
14AAE	0.0530	0.	0.0530	0.0351	0.0237	0.0144	0.0128
14AAF	0.0440	0.	0.0440	0.0309	0.0209	0.0125	0.0110
14AAG-01	0.0470	0.	0.0470	0.0324	0.0219	0.0054	0.0037
14AAH	0.0160	0.	0.0160	0.0099	0.0067	0.0018	0.0014
14AAK	0.0200	0.	0.0200	0.0168	0.0113	0.0017	0.
14ABA	0.2130	0.4548	0.2735	0.3983	0.2692	0.3191	0.3227
14ABB	0.0820	0.0650	0.0777	0.0725	0.0490	0.0421	0.0419
14AC0	0.0480	0.	0.0480	0.0328	0.0222	0.0072	0.0055
14AD0	0.5500	0.1038	0.4384	0.1746	0.1180	0.2509	0.2474
14ADA	0.0080	0.	0.0080	0.0074	0.0050	0.0106	0.0110
14ADB	0.0140	0.	0.0140	0.0123	0.0083	0.0066	0.0055
14ADC	0.0260	0.	0.0260	0.0208	0.0141	0.0035	0.0018
14ADD	0.0090	0.	0.0090	0.0083	0.0056	0.0108	0.0110
14ADE	0.0130	0.	0.0130	0.0116	0.0078	0.0473	0.0513
14ADF	0.0100	0.	0.0100	0.0091	0.0062	0.0047	0.0037
14AE0	0.1370	0.1038	0.1287	0.1181	0.0798	0.1049	0.1044
14AF0	0.1420	0.	0.1420	0.0600	0.0405	0.1878	0.1851
14AFA	0.0040	0.	0.0040	0.0031	0.0021	0.0011	0.0009
14AG0	0.0670	0.	0.0670	0.0228	0.0154	0.0209	0.0202
14AGA	0.0100	0.	0.0100	0.0046	0.0031	0.0011	0.0009
14AJ0	0.0480	0.	0.0480	0.0376	0.0254	0.0054	0.
14AL0	0.0800	0.	0.0800	0.0452	0.0305	0.0018	0.
14BA0	0.2000	0.	0.2000	0.0683	0.0462	0.0277	0.0257
14BAA	0.1200	0.	0.1200	0.0557	0.0376	0.0037	0.0018
14BAB	0.0800	0.	0.0800	0.0452	0.0305	0.0128	0.0110
14BB0	0.2000	0.	0.2000	0.0412	0.0278	0.0585	0.0568
14BBA	0.2000	0.	0.2000	0.0412	0.0278	0.0019	0.0009
14BBB	0.0150	0.	0.0150	0.0095	0.0064	0.0023	0.0018
14BC0	0.2000	0.1038	0.1759	0.1236	0.0835	0.0455	0.0458
14BCA	0.2000	0.	0.2000	0.0412	0.0278	0.0009	0.
14BCB	0.0150	0.	0.0150	0.0095	0.0064	0.0027	0.0023
14CA0	0.1550	0.	0.1550	0.0622	0.0420	0.0037	0.0018
14CB0	0.0960	0.	0.0960	0.0337	0.0228	0.0065	0.0055
14CC0	0.1010	0.	0.1010	0.0343	0.0232	0.0009	0.
14DA0	0.7440	0.	0.7440	0.0911	0.0615	0.0633	0.0605

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
14DAA	0.1310	0.	0.1310	0.0579	0.0391	0.0239	0.0220
14DAB	0.3200	0.	0.3200	0.0447	0.0302	0.0084	0.0073
14DAC	0.0160	0.	0.0160	0.0139	0.0094	0.0033	0.0018
14DC0	0.0210	0.	0.0210	0.0150	0.0101	0.0009	0.
14DD0	0.0200	0.	0.0200	0.0113	0.0076	0.0041	0.0037
14DE0	0.0200	0.	0.0200	0.0113	0.0076	0.0032	0.0028
14DG0-01	0.0710	0.	0.0710	0.0422	0.0285	0.0055	0.0037
14DG0-02	0.0710	0.	0.0710	0.0422	0.0285	0.0018	0.
14DH0	0.0950	0.	0.0950	0.0336	0.0227	0.0055	0.0046
14EA0-01	0.0173	0.	0.0173	0.0148	0.0100	0.0034	0.0018
14EA0-02	0.0173	0.	0.0173	0.0148	0.0100	0.0017	0.
14EB0	0.0500	0.	0.0500	0.0337	0.0228	0.0144	0.0128
14EC0-01	0.0380	0.	0.0380	0.0278	0.0188	0.0018	0.
14EC0-02	0.0800	0.	0.0800	0.0452	0.0305	0.0018	0.
14ED0-01	0.0380	0.	0.0380	0.0278	0.0188	0.0089	0.0073
14ED0-02	0.0380	0.	0.0380	0.0278	0.0188	0.0018	0.
14EH0	0.0080	0.	0.0080	0.0069	0.0047	0.0008	0.
14EJ0	0.0080	0.	0.0080	0.0069	0.0047	0.0008	0.
14EK0-01	0.0040	0.	0.0040	0.0039	0.0026	0.0013	0.
14EK0-02	0.0040	0.	0.0040	0.0039	0.0026	0.0013	0.
14EL0-01	0.0020	0.	0.0020	0.0020	0.0013	0.0019	0.0018
14EL0-02	0.0020	0.	0.0020	0.0020	0.0013	0.0010	0.
14EM0-01	0.0020	0.	0.0020	0.0020	0.0013	0.0010	0.
14EM0-02	0.0020	0.	0.0020	0.0020	0.0013	0.0010	0.
14FB0	0.7500	0.6227	0.7182	0.6382	0.4312	0.3200	0.3243
14FBA	0.0090	0.	0.0090	0.0067	0.0045	0.0018	0.0014
14FBB	0.0120	0.	0.0120	0.0082	0.0056	0.0027	0.0023
14FBC	0.0100	0.	0.0100	0.0091	0.0062	0.0031	0.0018
14FBD	0.0080	0.	0.0080	0.0065	0.0044	0.0017	0.0012
14FBE	0.0120	0.	0.0120	0.0098	0.0066	0.0087	0.0082
14FBF	0.0110	0.	0.0110	0.0100	0.0067	0.0064	0.0055
14FBG	0.0080	0.	0.0080	0.0074	0.0050	0.0015	0.
14FBH	0.0080	0.	0.0080	0.0074	0.0050	0.0045	0.0037
14FBJ	0.0040	0.0346	0.0117	0.0072	0.0048	0.0027	0.0031
14FBK	0.0210	0.	0.0210	0.0175	0.0118	0.0034	0.0018
14FBM	0.0080	0.	0.0080	0.0074	0.0050	0.0227	0.0257
14FBQ	0.0060	0.	0.0060	0.0057	0.0038	0.0043	0.0037
14FBR	0.0280	0.	0.0280	0.0221	0.0149	0.0018	0.
14FBS	0.0210	0.	0.0210	0.0175	0.0118	0.0017	0.
14FBT	0.0180	0.	0.0180	0.0153	0.0104	0.0017	0.
14FC0	0.4000	0.2076	0.3519	0.2472	0.1671	0.0613	0.0623
14FCA	0.0050	0.	0.0050	0.0048	0.0032	0.0027	0.0018
14FCC	0.0230	0.	0.0230	0.0138	0.0093	0.0024	0.0018
14FCD	0.0230	0.	0.0230	0.0138	0.0093	0.0030	0.0024
14FCE	0.0230	0.	0.0230	0.0188	0.0127	0.0035	0.0018
14FCF	0.0230	0.	0.0230	0.0188	0.0127	0.0035	0.0018
14FD0	0.0110	0.0519	0.0212	0.0182	0.0123	0.0765	0.0815
14FF0	0.2220	0.2076	0.2184	0.2122	0.1434	0.0056	0.0073
14FG0	0.1670	0.1038	0.1512	0.1280	0.0865	0.0148	0.0147
14FJ0	0.0360	0.	0.0360	0.0267	0.0181	0.0036	0.0018

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
14FK0	0.0020	0.	0.0020	0.0020	0.0013	0.0010	0.
14GA0	0.0010	0.	0.0010	0.0010	0.0007	0.0065	0.0165
14GB0	0.0010	0.	0.0010	0.0010	0.0007	0.0026	0.0055
231AA	0.0840	0.	0.0840	0.0366	0.0248	0.0239	0.0224
231AB	0.3330	0.	0.3330	0.0544	0.0367	0.0156	0.0140
231BA	0.0330	0.	0.0330	0.0250	0.0169	0.0283	0.0275
231BC	0.0039	0.	0.0039	0.0038	0.0026	0.0095	0.0177
231BG	0.0300	0.	0.0300	0.0233	0.0157	0.0176	0.0165
231BH	0.0800	0.	0.0800	0.0452	0.0305	0.0201	0.0183
231BJ	0.1000	1.2995	0.3999	0.8271	0.5589	0.3083	0.3325
231CA	0.0050	0.	0.0050	0.0048	0.0032	0.0082	0.0092
231CB	0.0120	0.	0.0120	0.0108	0.0073	0.0016	0.
231DA	0.0200	0.	0.0200	0.0144	0.0098	0.0009	0.
231DB	0.2000	0.	0.2000	0.0412	0.0278	0.0009	0.
231DC	0.0200	0.	0.0200	0.0144	0.0098	0.0009	0.
231DD	0.0200	0.	0.0200	0.0168	0.0113	0.0034	0.0018
231DE	0.0200	0.	0.0200	0.0168	0.0113	0.0017	0.
231DF	0.1200	0.	0.1200	0.0557	0.0376	0.0018	0.
231ED	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
231FA	0.2500	0.	0.2500	0.0733	0.0496	0.0056	0.0037
24AA0	0.0180	0.	0.0180	0.0153	0.0104	0.0034	0.0018
24AC0	0.0100	0.	0.0100	0.0091	0.0062	0.0047	0.0037
24AD0	0.0020	0.1038	0.0274	0.0039	0.0027	0.0347	0.0660
24BA0	0.2200	0.	0.2200	0.0705	0.0477	0.0019	0.
24BD0	0.1850	0.	0.1850	0.0665	0.0449	0.0092	0.0073
24BE0	0.1980	0.1038	0.1744	0.1362	0.0920	0.1626	0.1612
24BG0	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
24CA0	0.0060	0.1038	0.0304	0.0113	0.0077	0.0114	0.0147
24CB0	0.0490	0.1038	0.0627	0.0666	0.0450	0.0216	0.0220
24CD0	0.0100	0.	0.0100	0.0091	0.0062	0.0031	0.0018
24CE0	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
24DA0	0.3800	0.1038	0.3109	0.1630	0.1102	0.0223	0.0220
24DBA	0.1395	0.1038	0.1306	0.1190	0.0804	0.0166	0.0165
24DBB	0.0315	0.	0.0315	0.0196	0.0132	0.0045	0.0037
24DBC	0.0315	0.	0.0315	0.0196	0.0132	0.0018	0.0009
24DBD	0.0630	0.	0.0630	0.0392	0.0265	0.0036	0.0018
24DC0	0.0300	0.4152	0.1263	0.1164	0.0786	0.1177	0.1283
24DDA	0.0020	0.	0.0020	0.0020	0.0013	0.0039	0.0055
24DDB	0.0400	0.	0.0400	0.0289	0.0195	0.0054	0.0037
24DDD	0.1270	0.	0.1270	0.0571	0.0386	0.1213	0.1191
24DDE	0.1270	0.	0.1270	0.0571	0.0386	0.0092	0.0073
24DDJ	0.1020	0.	0.1020	0.0514	0.0348	0.1282	0.1264
24DDK	0.0510	0.1038	0.0642	0.0684	0.0462	0.0342	0.0348
24DDL	0.0160	0.	0.0160	0.0139	0.0094	0.0033	0.0018
24DDN	0.0120	0.	0.0120	0.0108	0.0073	0.0097	0.0092
24DEA	0.0100	0.	0.0100	0.0091	0.0062	0.0110	0.0110
24DFA	0.1270	0.	0.1270	0.0571	0.0386	0.0037	0.0018
24DFC	0.0780	0.	0.0780	0.0445	0.0301	0.0036	0.0018
24DFD	0.0340	0.	0.0340	0.0256	0.0173	0.0336	0.0330
24DG0	0.0010	0.	0.0010	0.0010	0.0007	0.0026	0.0055

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
24DGD	0.0140	0.1557	0.0494	0.0441	0.0298	0.0061	0.0082
24DH0	0.0510	0.	0.0510	0.0342	0.0231	0.0090	0.0073
24EA0	0.1470	0.	0.1470	0.0608	0.0411	0.0037	0.0018
24EAH	0.2500	0.1038	0.2134	0.1467	0.0991	0.0019	0.0018
24EBA	0.1000	0.	0.1000	0.0509	0.0344	0.0037	0.0018
41AAA	0.1450	0.	0.1450	0.0605	0.0409	0.0350	0.0330
41AAB	0.1450	0.	0.1450	0.0605	0.0409	0.0258	0.0238
41AAC	0.0460	0.	0.0460	0.0319	0.0215	0.0072	0.0055
41AAD	0.0360	0.	0.0360	0.0267	0.0181	0.0053	0.0037
41AAE	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
41AAJ	0.1250	0.	0.1250	0.0567	0.0383	0.0018	0.
41AAL	0.0250	0.	0.0250	0.0073	0.0049	0.0015	0.0013
41ABA	0.2600	0.	0.2600	0.0742	0.0501	0.1315	0.1283
41ABB	0.0380	0.	0.0380	0.0278	0.0188	0.0036	0.0018
41ABC	0.0150	0.	0.0150	0.0131	0.0089	0.0033	0.0018
41ABD	0.0750	0.	0.0750	0.0435	0.0294	0.0018	0.
41ABE	0.0560	0.	0.0560	0.0364	0.0246	0.0199	0.0183
41ABF	0.0860	0.1038	0.0904	0.0941	0.0636	0.0237	0.0238
41ABH	0.1250	0.	0.1250	0.0567	0.0383	0.0018	0.
41ABM	0.0050	0.	0.0050	0.0032	0.0021	0.0003	0.0002
41ACA	0.0630	0.1038	0.0732	0.0784	0.0530	0.0399	0.0403
41ACB	0.0400	0.	0.0400	0.0289	0.0195	0.0071	0.0055
41ACN	0.0010	0.	0.0010	0.0010	0.0007	0.0007	0.
41ADA	0.0040	0.	0.0040	0.0039	0.0026	0.0127	0.0165
41ADB	0.2000	0.1038	0.1759	0.1367	0.0923	0.0240	0.0238
41ADC	0.0380	0.	0.0380	0.0278	0.0188	0.0320	0.0312
41BAA	0.0500	0.1038	0.0634	0.0675	0.0456	0.0108	0.0110
41BAB	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
41BBA	0.0310	0.	0.0310	0.0239	0.0161	0.0264	0.0257
41CAA	0.0560	0.	0.0560	0.0364	0.0246	0.0108	0.0092
41CBA	0.0040	0.	0.0040	0.0039	0.0026	0.0025	0.0018
41DA0	0.0240	0.	0.0240	0.0195	0.0132	0.0017	0.
42AA0	0.1550	0.	0.1550	0.0622	0.0420	0.1106	0.1081
42AB0	0.1600	0.2076	0.1719	0.1889	0.1276	0.1014	0.1026
42BA0	0.0450	0.	0.0450	0.0314	0.0212	0.0269	0.0257
42CA0	0.2750	0.	0.2750	0.0753	0.0509	0.0074	0.0055
42DC0	0.1000	0.	0.1000	0.0509	0.0344	0.0037	0.0018
42DD0-01	0.0840	0.	0.0840	0.0634	0.0428	0.0026	0.
42DD0-02	0.0840	0.	0.0840	0.0566	0.0383	0.0057	0.
42DE0-01	0.0910	0.	0.0910	0.0673	0.0454	0.0026	0.
42DE0-02	0.0910	0.	0.0910	0.0597	0.0404	0.0057	0.
42EA0	0.0650	0.	0.0650	0.0400	0.0270	0.0054	0.0037
42FA0	0.0040	0.0519	0.0160	0.0074	0.0050	0.0008	0.0009
42FB0	0.0040	0.	0.0040	0.0039	0.0026	0.0038	0.0037
42GB0	0.0100	0.	0.0100	0.0091	0.0062	0.0456	0.0513
42HA0-01	0.1030	0.	0.1030	0.0736	0.0497	0.0026	0.
42HA0-02	0.1030	0.	0.1030	0.0647	0.0437	0.0058	0.
42HB0-01	0.1040	0.	0.1040	0.0741	0.0501	0.0105	0.0080
42HB0-02	0.1040	0.	0.1040	0.0651	0.0440	0.0058	0.
42HC0-01	0.2750	0.	0.2750	0.1330	0.0899	0.0053	0.0027

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
42HC0-02	0.2750	0.	0.2750	0.1065	0.0720	0.0060	0.
42JA0	0.3940	0.4152	0.3993	0.4138	0.2797	0.0922	0.0976
42KA0	0.0040	0.1038	0.0289	0.0077	0.0052	0.0064	0.0092
42KC0	0.0040	0.	0.0040	0.0039	0.0026	0.0064	0.0073
44AAA	0.1820	0.1038	0.1624	0.1322	0.0893	0.0388	0.0385
44AAB	0.3340	0.	0.3340	0.0792	0.0535	0.0056	0.0037
44AAC-01	0.5000	0.	0.5000	0.0860	0.0581	0.0204	0.0183
44AAC-02	0.5000	0.	0.5000	0.0860	0.0581	0.0019	0.
44AAD-01	0.0610	0.	0.0610	0.0493	0.0333	0.0155	0.0133
44AAD-02	0.0610	0.	0.0610	0.0452	0.0305	0.0055	0.
44AAE-01	0.0750	0.3114	0.1341	0.1742	0.1177	0.1019	0.1063
44AAE-02	0.0750	0.	0.0750	0.0435	0.0294	0.0018	0.
44AAF	0.4500	0.	0.4500	0.0843	0.0570	0.0242	0.0220
44AAG	0.1300	0.	0.1300	0.0577	0.0390	0.0074	0.0055
44AAH-01	0.0750	0.	0.0750	0.0435	0.0294	0.0200	0.0183
44AAH-02	0.0750	0.	0.0750	0.0435	0.0294	0.0018	0.
44AAJ	0.0180	0.	0.0180	0.0153	0.0104	0.0034	0.0018
44AC0	0.1260	0.	0.1260	0.0569	0.0385	0.0184	0.0165
44BA0-01	0.1750	0.	0.1750	0.0652	0.0440	0.0794	0.0770
44BA0-02	0.1760	0.	0.1760	0.0874	0.0591	0.0059	0.
44BB0	0.2750	0.	0.2750	0.0753	0.0509	0.0167	0.0147
44BC0	0.0670	0.	0.0670	0.0330	0.0223	0.0196	0.0182
44CA0	0.2500	0.	0.2500	0.0516	0.0349	0.0185	0.0168
44CB0	0.0530	0.	0.0530	0.0292	0.0197	0.0236	0.0224
44CC0	0.2660	0.	0.2660	0.0522	0.0353	0.0199	0.0182
44CD0	0.1940	0.	0.1940	0.0487	0.0329	0.0227	0.0210
45A99-01	0.0300	0.	0.0300	0.0233	0.0157	0.0035	0.0018
45A99-03	0.0030	0.	0.0030	0.0029	0.0020	0.0012	0.
45AAA	0.1020	0.	0.1020	0.0344	0.0232	0.0111	0.0101
45AAB	0.0200	0.	0.0200	0.0168	0.0113	0.0495	0.0513
45AAC	0.0370	0.	0.0370	0.0216	0.0146	0.0555	0.0550
45AAD	0.0340	0.	0.0340	0.0205	0.0139	0.0136	0.0128
45AAE	0.0950	0.	0.0950	0.0336	0.0227	0.0055	0.0046
45AEA	0.0080	0.	0.0080	0.0069	0.0047	0.0025	0.0018
45AEB	0.0180	0.	0.0180	0.0106	0.0072	0.0005	0.
45AEC	0.0030	0.	0.0030	0.0028	0.0019	0.0029	0.0028
45AEN	0.0080	0.	0.0080	0.0074	0.0050	0.0061	0.0055
45AG0	0.1670	0.	0.1670	0.0640	0.0433	0.0314	0.0293
45AH0	0.1670	0.	0.1670	0.0640	0.0433	0.0406	0.0385
45AJ0	0.0500	0.	0.0500	0.0255	0.0172	0.0037	0.0028
45AK0	0.0260	0.	0.0260	0.0173	0.0117	0.0018	0.0009
45AL0	0.0250	0.	0.0250	0.0169	0.0114	0.0054	0.0046
45AM0	0.2050	0.	0.2050	0.0689	0.0466	0.0019	0.
45B99-01	0.0250	0.	0.0250	0.0202	0.0136	0.0035	0.0018
45BAF	0.1330	0.	0.1330	0.0583	0.0394	0.0018	0.
46AA0	0.0470	0.	0.0470	0.0167	0.0113	0.0005	0.
46AB0	0.0470	0.1038	0.0612	0.0740	0.0500	0.0037	0.0046
46AC0	0.0140	0.	0.0140	0.0110	0.0075	0.0026	0.0018
46AE0	0.0200	0.	0.0200	0.0127	0.0086	0.0048	0.0043
46AF0	0.0490	0.	0.0490	0.0333	0.0225	0.0431	0.0421

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
46AFA	0.0300	0.	0.0300	0.0233	0.0157	0.0035	0.0018
46AHO	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
46AJO	0.0760	0.	0.0760	0.0141	0.0095	0.0003	0.
46AKO	0.0500	0.	0.0500	0.0337	0.0228	0.0018	0.
46ANO	0.0490	0.	0.0490	0.0333	0.0225	0.0018	0.
46APO	0.0230	0.2076	0.0691	0.0565	0.0382	0.0035	0.0055
46AQO	0.0030	0.	0.0030	0.0029	0.0020	0.0058	0.0073
46BBO	0.3350	0.	0.3350	0.0792	0.0535	0.0037	0.0018
46BCO	0.0320	0.	0.0320	0.0245	0.0165	0.0018	0.
46BDO	0.0280	0.	0.0280	0.0221	0.0149	0.0035	0.0018
46BTO	0.0760	0.	0.0760	0.0141	0.0095	0.0003	0.
46BUO	0.0470	0.	0.0470	0.0167	0.0113	0.0009	0.0005
46BVO	0.0410	0.	0.0410	0.0229	0.0155	0.0009	0.
46BWO	0.0050	0.	0.0050	0.0046	0.0031	0.0008	0.
46CAO	0.0850	0.	0.0850	0.0467	0.0316	0.0037	0.0018
46CBO	0.0945	0.	0.0945	0.0495	0.0334	0.0018	0.
46CJO	0.0760	0.	0.0760	0.0141	0.0095	0.0003	0.
46CNO	0.1240	0.	0.1240	0.0565	0.0382	0.0110	0.0092
46CPO	0.0100	0.	0.0100	0.0091	0.0062	0.0063	0.0055
46CQO	0.0760	0.	0.0760	0.0141	0.0095	0.0003	0.
46CRO	0.0830	0.	0.0830	0.0461	0.0312	0.0018	0.
46DBO	0.0500	0.	0.0500	0.0419	0.0283	0.0051	0.0027
46DCO	0.0500	0.	0.0500	0.0388	0.0262	0.0054	0.
46EAO	0.0020	0.2577	0.0659	0.0040	0.0027	0.0023	0.0053
46EBO	0.0030	0.	0.0030	0.0029	0.0020	0.0058	0.0073
46EEO	0.1080	0.	0.1080	0.0529	0.0358	0.0587	0.0568
46EGO	0.0410	0.	0.0410	0.0354	0.0239	0.1363	0.1410
46EHO	0.0310	0.	0.0310	0.0263	0.0178	0.1018	0.1118
46EJO	0.2100	0.2577	0.2219	0.2314	0.1564	0.0504	0.0506
46EKO	0.2100	0.	0.2100	0.0615	0.0415	0.0270	0.0235
46EPO	0.0020	0.	0.0020	0.0020	0.0013	0.0010	0.
46EVO	0.1050	0.	0.1050	0.0401	0.0271	0.0113	0.0098
46EYO	0.0010	0.	0.0010	0.0010	0.0007	0.0029	0.0080
46FAO	0.2000	0.	0.2000	0.0412	0.0278	0.2116	0.2080
46FBO	0.0740	0.	0.0740	0.0305	0.0206	0.0249	0.0238
46FBA	0.0070	0.	0.0070	0.0062	0.0042	0.0025	0.0018
46FBB	0.0030	0.	0.0030	0.0028	0.0019	0.0036	0.0037
51ACO	0.1850	0.	0.1850	0.0481	0.0325	0.0694	0.0671
51BBO	0.5700	0.1300	0.4600	0.1750	0.1182	0.1026	0.1020
51CCO	0.1450	0.	0.1450	0.0449	0.0303	0.0170	0.0154
51EAO	0.0800	0.	0.0800	0.0452	0.0305	0.0182	0.0165
51EAB	0.0210	0.	0.0210	0.0159	0.0107	0.0013	0.
51EAC	0.0180	0.	0.0180	0.0153	0.0104	0.0017	0.
51EBO	0.0800	0.	0.0800	0.0548	0.0370	0.0283	0.0235
51EBB	0.0210	0.	0.0210	0.0159	0.0107	0.0013	0.
51EBC	0.0030	0.	0.0030	0.0030	0.0020	0.0020	0.
51FAO	0.4500	0.1038	0.3634	0.1687	0.1140	0.1895	0.1869
51FAA	0.0170	0.	0.0170	0.0146	0.0099	0.0017	0.
51FAB	0.0130	0.	0.0130	0.0116	0.0078	0.0049	0.0037
51FAC	0.0120	0.	0.0120	0.0098	0.0066	0.0026	0.0018

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
51FAD	0.0110	0.	0.0110	0.0100	0.0067	0.0064	0.0055
51FAE	0.0080	0.	0.0080	0.0074	0.0050	0.0045	0.0037
51FAF	0.0130	0.	0.0130	0.0104	0.0070	0.0017	0.0009
51FAH	0.0380	0.	0.0380	0.0278	0.0188	0.0036	0.0018
51FAJ	0.0150	0.	0.0150	0.0131	0.0089	0.0083	0.0073
51FAK	0.0090	0.	0.0090	0.0083	0.0056	0.0046	0.0037
51FAL	0.0120	0.	0.0120	0.0108	0.0073	0.0048	0.0037
51FAM	0.0360	0.	0.0360	0.0267	0.0181	0.0106	0.0092
51FAN	0.0050	0.	0.0050	0.0048	0.0032	0.0041	0.0037
51FAP	0.0050	0.	0.0050	0.0048	0.0032	0.0082	0.0092
51FAQ	0.0100	0.	0.0100	0.0091	0.0062	0.0079	0.0073
55AAB	0.0010	0.	0.0010	0.0010	0.0007	0.0013	0.0018
55ABA	0.0010	0.	0.0010	0.0010	0.0007	0.0007	0.
55ABB	0.0340	0.	0.0340	0.0256	0.0173	0.0106	0.0092
62ABO	0.0095	0.	0.0095	0.0087	0.0059	0.0016	0.
63ABO	0.0480	0.	0.0480	0.0276	0.0187	0.0125	0.0112
63ADO	0.0460	0.1038	0.0604	0.0638	0.0431	0.0036	0.0037
63AEO	0.2860	0.	0.2860	0.0762	0.0515	0.0074	0.0055
63AJO	0.0400	0.	0.0400	0.0289	0.0195	0.0018	0.
64AEO	0.0200	0.	0.0200	0.0168	0.0113	0.0137	0.0128
64AFO	0.0200	0.2076	0.0669	0.0503	0.0340	0.0137	0.0165
64AGO	0.3000	0.	0.3000	0.1100	0.0744	0.0537	0.0471
64AHO	0.0200	0.	0.0200	0.0179	0.0121	0.0420	0.0471
71BAO	0.1190	0.1038	0.1152	0.1109	0.0749	0.0643	0.0641
71BBO	0.0100	0.	0.0100	0.0091	0.0062	0.0063	0.0055
71BCO	0.0300	0.	0.0300	0.0205	0.0139	0.0382	0.0377
74AAO	0.5800	1.9720	0.9280	1.7607	1.1897	0.8236	0.8447
74AAA	0.0210	0.	0.0210	0.0175	0.0118	0.0171	0.0165
74AAB	0.0440	0.	0.0440	0.0309	0.0209	0.0090	0.0073
74AAC	0.0230	0.	0.0230	0.0188	0.0127	0.0052	0.0037
74AAD	0.0350	0.	0.0350	0.0262	0.0177	0.0832	0.0843
74AAE	0.0270	0.	0.0270	0.0214	0.0145	0.0105	0.0092
74ABO	1.6000	1.3493	1.5373	1.3645	0.9220	0.7992	0.8080
74ABA	0.0600	0.	0.0600	0.0380	0.0257	0.0253	0.0238
74ABB	0.0570	0.	0.0570	0.0368	0.0249	0.0271	0.0257
74ABC	0.0110	0.	0.0110	0.0091	0.0061	0.0146	0.0147
74ABD	0.2190	0.	0.2190	0.0704	0.0476	0.0351	0.0330
74ABE	0.0410	0.	0.0410	0.0294	0.0199	0.0446	0.0440
74ABF	0.0530	0.	0.0530	0.0351	0.0237	0.0270	0.0257
74ABG	0.0430	0.	0.0430	0.0304	0.0205	0.0179	0.0165
74ABH	0.0110	0.	0.0110	0.0100	0.0067	0.0016	0.
74ABJ	0.0640	0.	0.0640	0.0396	0.0268	0.0091	0.0073
74ABM	0.0680	0.	0.0680	0.0411	0.0278	0.0127	0.0110
74ABN	0.0360	0.	0.0360	0.0267	0.0181	0.0231	0.0220
74ACO	1.1860	1.4530	1.2528	1.4315	0.9673	0.5568	0.5717
74ACB	0.0480	0.	0.0480	0.0328	0.0222	0.0018	0.
74ACC	0.0140	0.	0.0140	0.0123	0.0083	0.0017	0.
74ACD	0.0090	0.	0.0090	0.0083	0.0056	0.0015	0.
74ACG	0.0130	0.	0.0130	0.0116	0.0078	0.0016	0.
74ACH	0.3540	0.	0.3540	0.0803	0.0542	0.0019	0.

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
74AD0	1.7070	0.6227	1.4359	0.6849	0.4628	0.4062	0.4086
74ADB	0.0190	0.	0.0190	0.0161	0.0109	0.0034	0.0018
74ADC	0.0390	0.	0.0390	0.0156	0.0105	0.0009	0.0005
74ADD	0.0140	0.	0.0140	0.0123	0.0083	0.0017	0.
74ADE	0.0440	0.	0.0440	0.0309	0.0209	0.0018	0.
74ADF	0.0430	0.	0.0430	0.0304	0.0205	0.0018	0.
74ADG	0.0130	0.	0.0130	0.0116	0.0078	0.0016	0.
74ADH	0.0100	0.	0.0100	0.0091	0.0062	0.0063	0.0055
74ADJ	0.0190	0.	0.0190	0.0161	0.0109	0.0017	0.
74ADK	0.0100	0.	0.0100	0.0091	0.0062	0.0031	0.0018
74ADL	0.0110	0.	0.0110	0.0100	0.0067	0.0048	0.0037
74ADM	0.0100	0.	0.0100	0.0084	0.0057	0.0094	0.0092
74ADN	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
74ADP	0.0130	0.	0.0130	0.0116	0.0078	0.0016	0.
74ADQ	0.0090	0.	0.0090	0.0083	0.0056	0.0093	0.0092
74ADR	0.0120	0.	0.0120	0.0108	0.0073	0.0048	0.0037
74ADS	0.0120	0.	0.0120	0.0108	0.0073	0.0032	0.0018
74ADT	0.0130	0.	0.0130	0.0116	0.0078	0.0016	0.
74ADU	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
74ADV	0.0090	0.	0.0090	0.0083	0.0056	0.0031	0.0018
74ADW	0.0240	0.	0.0240	0.0164	0.0111	0.0027	0.0018
74ADX	0.0240	0.	0.0240	0.0195	0.0132	0.0017	0.
74ADY	0.0240	0.	0.0240	0.0195	0.0132	0.0017	0.
74ADZ	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
74AEA	0.0290	0.	0.0290	0.0158	0.0107	0.0006	0.
74AEB	0.0140	0.	0.0140	0.0123	0.0083	0.0049	0.0037
74AEC	0.0330	0.	0.0330	0.0250	0.0169	0.0018	0.
74AED	0.0560	0.	0.0560	0.0364	0.0246	0.0199	0.0183
74AF0	0.5570	1.1417	0.7032	1.0498	0.7094	0.4908	0.5020
74AFA	0.0180	0.	0.0180	0.0153	0.0104	0.0034	0.0018
74AFB	0.0080	0.	0.0080	0.0074	0.0050	0.0045	0.0037
74AFC	0.0110	0.	0.0110	0.0100	0.0067	0.0016	0.
74AFD	0.0110	0.	0.0110	0.0100	0.0067	0.0032	0.0018
74AFE	0.0110	0.	0.0110	0.0100	0.0067	0.0032	0.0018
74AFF	0.0320	0.	0.0320	0.0245	0.0165	0.0071	0.0055
74AFG	0.0150	0.	0.0150	0.0131	0.0089	0.0116	0.0110
74AFH	0.0150	0.	0.0150	0.0131	0.0089	0.0066	0.0055
74AFJ	0.0110	0.	0.0110	0.0100	0.0067	0.0048	0.0037
74AFK	0.0140	0.	0.0140	0.0123	0.0083	0.0082	0.0073
74AFL	0.0370	0.	0.0370	0.0273	0.0184	0.0018	0.
74AFM	0.0370	0.	0.0370	0.0273	0.0184	0.0018	0.
74AH0	0.1860	0.1038	0.1654	0.1332	0.0900	0.0499	0.0495
74AJ0	0.1020	0.1038	0.1024	0.1029	0.0695	0.0385	0.0385
74AJB	0.0020	0.	0.0020	0.0020	0.0013	0.0019	0.0018
74AJC	0.0080	0.	0.0080	0.0074	0.0050	0.0045	0.0037
74AL0	0.0170	0.	0.0170	0.0146	0.0099	0.0387	0.0403
74BA0	2.0000	1.5568	1.8892	1.5787	1.0668	0.3783	0.3976
74BAA	0.2190	0.	0.2190	0.0704	0.0476	0.0056	0.0037
74BAB	0.1790	0.	0.1790	0.0657	0.0444	0.0240	0.0220
74BAC	0.0420	0.	0.0420	0.0299	0.0202	0.0250	0.0238

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
74BAD	0.4720	0.	0.4720	0.0851	0.0575	0.0780	0.0751
74BAE	0.0780	0.	0.0780	0.0445	0.0301	0.0164	0.0147
74BAF	0.0320	0.	0.0320	0.0245	0.0165	0.0141	0.0128
74BAG	0.0260	0.	0.0260	0.0208	0.0141	0.0035	0.0018
74BAJ	0.0150	0.	0.0150	0.0131	0.0089	0.0033	0.0018
74BBO	0.0100	0.	0.0100	0.0091	0.0062	0.0031	0.0018
74BCO	0.8000	0.3114	0.6778	0.3675	0.2483	0.2233	0.2235
74BC1	0.0420	0.	0.0420	0.0299	0.0202	0.0018	0.
74BC2	0.0030	0.	0.0030	0.0029	0.0020	0.0012	0.
74BC3	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
74BC4	0.0010	0.	0.0010	0.0010	0.0007	0.0007	0.
74BCA	0.0050	0.	0.0050	0.0048	0.0032	0.0014	0.
74BCB	0.0400	0.	0.0400	0.0226	0.0153	0.0009	0.
74BCC	0.0150	0.	0.0150	0.0131	0.0089	0.0017	0.
74BCD	0.0070	0.	0.0070	0.0066	0.0044	0.0030	0.0018
74BCE	0.0080	0.	0.0080	0.0074	0.0050	0.0015	0.
74BCG	0.0080	0.	0.0080	0.0074	0.0050	0.0015	0.
74BCH	0.0150	0.	0.0150	0.0116	0.0079	0.0009	0.
74BCJ	0.0080	0.	0.0080	0.0074	0.0050	0.0015	0.
74BCK	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
74BCL	0.0080	0.	0.0080	0.0074	0.0050	0.0015	0.
74BCM	0.0060	0.	0.0060	0.0057	0.0038	0.0014	0.
74BCN	0.0170	0.	0.0170	0.0146	0.0099	0.0017	0.
74BCZ	0.0730	0.	0.0730	0.0429	0.0290	0.0018	0.
74BDO	0.0260	0.	0.0260	0.0208	0.0141	0.0087	0.0073
74BEO	0.2300	0.	0.2300	0.0715	0.0483	0.1018	0.0989
74CAO	1.0000	1.3493	1.0873	1.3164	0.8895	0.4058	0.4214
74CAA	0.0220	0.	0.0220	0.0182	0.0123	0.0103	0.0092
74CAB	0.0420	0.	0.0420	0.0299	0.0202	0.0089	0.0073
74CAC	0.0360	0.	0.0360	0.0267	0.0181	0.0053	0.0037
74CAD	0.0100	0.	0.0100	0.0091	0.0062	0.0031	0.0018
74CAE	0.0630	0.	0.0630	0.0285	0.0192	0.0046	0.0037
74CAF	0.0110	0.	0.0110	0.0100	0.0067	0.0048	0.0037
74CAG	0.0260	0.	0.0260	0.0208	0.0141	0.0087	0.0073
74CAH	0.0230	0.	0.0230	0.0188	0.0127	0.0069	0.0055
74CAJ	0.0120	0.	0.0120	0.0098	0.0066	0.0017	0.0009
74CAK	0.0250	0.	0.0250	0.0202	0.0136	0.0069	0.0055
74CAL	0.0200	0.	0.0200	0.0168	0.0113	0.0017	0.
74CBO	0.0100	0.	0.0100	0.0091	0.0062	0.0031	0.0018
74DAO	2.0000	2.6985	2.1746	2.6640	1.8001	0.8534	0.8850
74DAA	0.2280	0.	0.2280	0.0713	0.0482	0.0037	0.0018
74DAF	0.1000	0.	0.1000	0.0509	0.0344	0.0073	0.0055
74DAG	0.0380	0.	0.0380	0.0278	0.0188	0.0071	0.0055
74DAH	0.0100	0.	0.0100	0.0091	0.0062	0.0094	0.0092
74DAJ	0.0110	0.	0.0110	0.0100	0.0067	0.0016	0.
74DAK	0.0380	0.	0.0380	0.0278	0.0188	0.0053	0.0037
74DAL	0.0330	0.	0.0330	0.0250	0.0169	0.0124	0.0110
74DAM	0.0150	0.	0.0150	0.0131	0.0089	0.0066	0.0055
74DAN	0.0220	0.	0.0220	0.0182	0.0123	0.0052	0.0037
74DAP	0.0120	0.	0.0120	0.0108	0.0073	0.0081	0.0073

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
74DAQ	0.0330	0.	0.0330	0.0250	0.0169	0.0053	0.0037
74DAR	0.0320	0.	0.0320	0.0245	0.0165	0.0035	0.0018
74DCO	0.0200	0.	0.0200	0.0168	0.0113	0.0137	0.0128
74DDO	1.1000	0.5189	0.9547	0.5690	0.3845	0.4152	0.4159
74DDA	0.0050	0.	0.0050	0.0048	0.0032	0.0054	0.0055
74DDB	0.0060	0.	0.0060	0.0057	0.0038	0.0171	0.0202
74DDC	0.0070	0.	0.0070	0.0066	0.0044	0.0177	0.0202
74DDD	0.0240	0.	0.0240	0.0195	0.0132	0.0156	0.0147
74DDE	0.0140	0.2076	0.0624	0.0370	0.0250	0.0263	0.0312
74DDF	0.0140	0.	0.0140	0.0123	0.0083	0.0115	0.0110
74DDG	0.0170	0.	0.0170	0.0146	0.0099	0.0151	0.0147
74EAO	1.6000	0.2599	1.2650	0.3122	0.2110	0.4437	0.4387
74EAA	0.0130	0.	0.0130	0.0108	0.0073	0.0206	0.0210
74EAB	0.0110	0.	0.0110	0.0094	0.0064	0.0164	0.0168
74EAC	0.0330	0.0650	0.0410	0.0438	0.0296	0.0780	0.0796
74EAD	0.0480	0.0650	0.0522	0.0552	0.0373	0.0222	0.0224
74EAE	0.2530	0.	0.2530	0.0517	0.0349	0.0781	0.0755
74EAF	0.1260	0.	0.1260	0.0429	0.0290	0.0226	0.0210
74EAG	0.0870	0.	0.0870	0.0372	0.0251	0.0197	0.0182
74EBO	2.0000	0.3114	1.5778	0.3947	0.2667	0.1938	0.1942
74EBA	0.0640	0.	0.0640	0.0396	0.0268	0.0145	0.0128
74EBB	0.0360	0.	0.0360	0.0213	0.0144	0.0046	0.0037
74EBD	0.0340	0.	0.0340	0.0256	0.0173	0.0053	0.0037
74EBE	0.0840	0.	0.0840	0.0464	0.0314	0.0037	0.0018
74EBF	0.0580	0.	0.0580	0.0372	0.0251	0.0072	0.0055
74EBG	0.1570	0.	0.1570	0.0625	0.0422	0.0092	0.0073
74EBH	0.0520	0.	0.0520	0.0346	0.0234	0.0090	0.0073
74EBJ	0.0700	0.	0.0700	0.0418	0.0283	0.0145	0.0128
74EBK	0.0700	0.	0.0700	0.0418	0.0283	0.0091	0.0073
74EBL	0.0430	0.	0.0430	0.0304	0.0205	0.0179	0.0165
74EBM	0.0440	0.	0.0440	0.0309	0.0209	0.0376	0.0366
74ECO	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
75AAA	0.1000	0.	0.1000	0.0509	0.0344	0.0018	0.
75ABA	0.0400	0.	0.0400	0.0289	0.0195	0.0018	0.
75ABB	0.5000	0.	0.5000	0.0860	0.0581	0.0019	0.
75ABC	0.4500	0.	0.4500	0.0843	0.0570	0.0037	0.0018
75ABD	0.2000	0.	0.2000	0.0683	0.0462	0.0019	0.
75ABE	0.0080	0.	0.0080	0.0074	0.0050	0.0015	0.
75ABF	0.0080	0.	0.0080	0.0074	0.0050	0.0030	0.0018
75ABG	0.0080	0.	0.0080	0.0069	0.0047	0.0008	0.
75ABH	0.0010	0.	0.0010	0.0010	0.0007	0.0007	0.
75ACA	0.1680	0.	0.1680	0.0642	0.0434	0.0018	0.
75ACB	0.0060	0.	0.0060	0.0057	0.0038	0.0043	0.0037
75ACC	0.0260	0.	0.0260	0.0208	0.0141	0.0052	0.0037
75ACD	0.0280	0.	0.0280	0.0221	0.0149	0.0070	0.0055
75ACE	0.0310	0.	0.0310	0.0239	0.0161	0.0053	0.0037
75ACH	0.0150	0.	0.0150	0.0131	0.0089	0.0017	0.
75ACJ	0.0280	0.	0.0280	0.0221	0.0149	0.0053	0.0037
75ADA	1.2000	0.	1.2000	0.0955	0.0646	0.0112	0.0092
75ADB	0.0160	0.	0.0160	0.0139	0.0094	0.0050	0.0037

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
75ADC	0.0200	0.	0.0200	0.0168	0.0113	0.0017	0.
75ADD	0.0100	0.	0.0100	0.0091	0.0062	0.0016	0.
75ADE	0.0200	0.	0.0200	0.0168	0.0113	0.0017	0.
75AFA	0.0180	0.	0.0180	0.0153	0.0104	0.0101	0.0092
75AFB	0.0180	0.	0.0180	0.0153	0.0104	0.0034	0.0018
75AFC	0.0120	0.1038	0.0349	0.0215	0.0145	0.0048	0.0055
75AFD	0.0040	0.	0.0040	0.0039	0.0026	0.0013	0.
75BA0	0.0690	0.0778	0.0712	0.0754	0.0510	0.0936	0.0934
75BB0	0.0070	0.	0.0070	0.0066	0.0044	0.0648	0.0788
75BD0	0.0010	0.0519	0.0137	0.0020	0.0013	0.0092	0.0174
75CA0	0.2280	0.	0.2280	0.0233	0.0157	0.0563	0.0550
75CB0	0.2280	0.2595	0.2359	0.2563	0.1732	0.0498	0.0531
75DA0	0.1460	0.4548	0.2232	0.3597	0.2431	0.0905	0.0978
75DAD	0.0030	0.0325	0.0104	0.0055	0.0037	0.0012	0.0014
75DAE	0.0050	0.	0.0050	0.0043	0.0029	0.0006	0.
75DB0	0.0290	0.1557	0.0607	0.0959	0.0648	0.0408	0.0431
75DBB	0.0050	0.	0.0050	0.0035	0.0024	0.0028	0.0027
75DBC	0.0070	0.	0.0070	0.0055	0.0037	0.0031	0.0028
75DC0	0.6450	1.4530	0.8470	1.3410	0.9062	0.8778	0.8886
75DCA	0.0050	0.0519	0.0167	0.0091	0.0062	0.0142	0.0165
75DCB	0.0070	0.	0.0070	0.0062	0.0042	0.0173	0.0183
75DCC	0.0230	0.	0.0230	0.0188	0.0127	0.0293	0.0293
75DCD	0.0360	0.	0.0360	0.0213	0.0144	0.0055	0.0046
75DCE	0.0020	0.2076	0.0534	0.0096	0.0065	0.0064	0.0119
75DCF	0.0100	0.0519	0.0205	0.0168	0.0113	0.0154	0.0165
75DCG	0.0020	0.	0.0020	0.0019	0.0013	0.0019	0.0018
75DCH	0.0020	0.	0.0020	0.0019	0.0013	0.0146	0.0202
75DCJ	0.0070	0.	0.0070	0.0062	0.0042	0.0033	0.0028
75DCM	0.0110	0.	0.0110	0.0091	0.0061	0.0215	0.0220
75DCS	0.0030	0.2076	0.0541	0.0088	0.0059	0.0138	0.0238
75DCT	0.0360	0.	0.0360	0.0213	0.0144	0.0036	0.0028
75DD0	0.0370	0.0519	0.0407	0.0432	0.0292	0.0610	0.0614
75DDB	0.0050	0.	0.0050	0.0035	0.0024	0.0008	0.0006
75DDC	0.0070	0.	0.0070	0.0062	0.0042	0.0132	0.0137
75DE0	0.0440	0.2595	0.0979	0.1429	0.0965	0.0712	0.0751
75DEB	0.0050	0.0115	0.0066	0.0070	0.0047	0.0014	0.0014
75DEC	0.0080	0.	0.0080	0.0069	0.0047	0.0033	0.0028
75DED	0.0020	0.	0.0020	0.0019	0.0013	0.0025	0.0028
75DFB	0.0050	0.	0.0050	0.0035	0.0024	0.0004	0.0002
75EA0	0.0010	0.2076	0.0526	0.0030	0.0020	0.0013	0.0055
75EB0	0.0010	0.	0.0010	0.0010	0.0007	0.0013	0.0018
75EC0	0.0010	0.	0.0010	0.0010	0.0007	0.0039	0.0092
75ED0	0.0030	0.	0.0030	0.0029	0.0020	0.0046	0.0055
75EE0	0.0030	0.	0.0030	0.0029	0.0020	0.0012	0.
75EF0	0.0030	0.	0.0030	0.0029	0.0020	0.0046	0.0055
75EG0	0.0010	0.	0.0010	0.0010	0.0007	0.0033	0.0073
75EH0	0.0030	0.	0.0030	0.0029	0.0020	0.0046	0.0055
75EJ0	0.0030	0.	0.0030	0.0029	0.0020	0.0035	0.0037
76AD0	0.0220	0.	0.0220	0.0182	0.0123	0.0017	0.
76AE0	0.0220	0.	0.0220	0.0164	0.0111	0.0013	0.

WUC	ORLA EST	6M MEAS	6M 7525	6M BAYES	6M B-L	24M 'ACT'	30M MEAS
76ALO	0.0100	0.	0.0100	0.0096	0.0065	0.0021	0.
76BAO	0.3630	0.2076	0.3241	0.2421	0.1636	0.0668	0.0678
76CCO	0.0100	0.	0.0100	0.0091	0.0062	0.0047	0.0037
76DAO	0.0400	0.	0.0400	0.0289	0.0195	0.0071	0.0055
76DBO	0.1600	0.	0.1600	0.0630	0.0425	0.0018	0.
76DCO	0.1140	0.1038	0.1114	0.1087	0.0734	0.0165	0.0165
76DDO	0.0610	0.	0.0610	0.0280	0.0190	0.0009	0.
76DEO	0.0140	0.	0.0140	0.0123	0.0083	0.0049	0.0037
76DGO	0.1300	0.	0.1300	0.0577	0.0390	0.0018	0.
76DHO	0.1300	0.	0.1300	0.0577	0.0390	0.0037	0.0018
NREADS=		810					

*

APPENDIX E

REFERENCES

1. Abell, John B., Brenda J. Allen, Brian E. Mansir and F. Michael Slay, "The Use of Availability Models in Initial Provisioning," Logistics Management Institute Report #ML108 (Washington, D.C.), April 1981.

2. Allen, Brenda J. and John B. Abell, "An Evaluation of Spares Acquisition Integrated with Production," Logistics Management Institute Report #ML108 (Washington, D.C.), August 1981.

3. Brown, G. F., Jr. and W. F. Rogers, "A Bayesian Approach to Demand Estimation and Inventory Provisioning," Naval Research Logistics Quarterly, 20: 607-624, 1973.

4. General Dynamics Report #16PR1103-1, "Work Unit Code/Work Breakdown Structure Cross Reference Listing For the F-16 Line Replaceable Units," June 1981.

5. General Dynamics Report #16PR147-30, "System Trade Study Report Reliability and Maintainability, Allocation Assessment and Analysis Report," Volume 1, November 1974.

6. General Dynamics Report #16PR147-30, "System Trade Study Report Reliability and Maintainability, Allocation Assessment and Analysis Report," Volume 2, November 1974.

7. Haber, Sheldon E. and Rosedith Sitgreaves, "A Methodology for Estimating Expected Usage of Repair Parts with Application to Parts with No Usage History," Naval Research Logistics Quarterly, 17: 535-546, 1970.

8. McGlothlin, W. H. and R. Radner, "The Use of Bayesian Techniques for Predicting Spare-Parts Demand," The RAND Corporation, RM-2536, March 1960.

9. Morris, W. T., Management Science: A Bayesian Introduction (Prentice-Hall, Englewood Cliffs, N.J.), 1968.

10. Raiffa, H. and R. Schlaifer, Applied Statistical Decision Theory, Graduate School of Business Administration, Harvard University, 1961.

11. Briefing Charts on "Requirements' Computation Procedures for Contract F33657-76-C-0191," Department of Defense, date unknown.

12. Briefing Charts on "FSD Reliability," Table XIII, Department of Defense, date unknown.

13. General Dynamics Report #F33657-75-C-0310, "Preliminary Technical Manual, Aircraft Maintenance Work Unit Code Manual," USAF/EPAF Series F-16A/B Aircraft, 20 October 1978.

14. Raiffa, Howard, Decision Analysis (Addison-Wesley, Reading, Mass.), 1968.